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PHILIPS

PM2422

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PHILIPS

Manual

DIGITAL MULTIMETER PM2422

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IMPORTANT

In correspondence concerning this instrument please quote the type number and the serial number as given on the type plate at the rear of the instrument.

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I. Introduction

GENERAL

Philips Digital Multimeter PM 2422 is an accurate 3 + 1 digit instrument with a maximum reading of 1499.

The instrument measures:

- DC and AC voltages of 150 mV ... 1000 V (AC 600 V) full scale, 5 ranges
- DC and AC currents of 150 μA ... 1.5 A full scale, 5 ranges
- Resistances of 150 Ω ... 15 MΩ full scale, 6 ranges
- DC high voltages up to 30 kV with the optional HT probe PM 9240
- UFH voltages up to 700 MHz with the optional UHF probe PM 9200. For measuring in coaxial lines T-connector PM 9250 is available.

Operation of the instrument is simple: selection of the measuring ranges is effected by one single rotary switch, and AC-DC selection is by push buttons.

Moreover, the polarity of direct voltages or currents is indicated automatically on a separate display. The position of the decimal point is indicated automatically.

An additional switch on the front panel permits of selection of the number of measurements per second (5 or 1) or the holding of the measured value.

On account of its specification, accuracy, and rugged construction the instrument is an ideal general-purpose multimeter for production lines or laboratories, for sevicing as well as for education.

II. Technical data

Properties expressed in numerical values with tolerances are guaranteed by the manufacturer. Numerical values without tolerances serve only for information and represent the properties of an average instrument.
The data below are applicable at 22 °C, unless otherwise stated.

A. MEASURING RANGES

1. Direct voltages

Measuring range	0.1 mV ... 1000 V 5 ranges: up to 150 mV, 1.5 V, 15 V, 150 V and 1 kV
Resolution	100 µV
Accuracy	± 0.1 % of full scale and ± 0.1 % of reading
Temperature coefficient	± 1 digit / 5 °C between 15° and 35 °C
Input resistance	10 MΩ ± 0.1 %
Series mode rejection	40 dB at 50 Hz
Common mode rejection	90 dB at 50 Hz 100 dB at DC

2. Alterning voltages

Measuring range	0.1 mV ... 600 V 5 ranges: up to 150 mV, 1.5 V, 15 V, 150 V and 600 V
Resolution	100 µV
Accuracy	+ 0.2 % of full scale + 0.2 % of reading } at a frequency of 1 kHz + 0.5 % of full scale + 0.5 % of reading } at frequences of 30 Hz ... 30 kHz
Input impedance	1 MΩ//50 pF
Temperature coefficient	± 1 digit/2 °C between 15° and 35 °C
Frequency range	30 Hz ... 30 kHz
Maximum input voltage	600 V

3. Direct currents

Measuring range	0.1 µA ... 1.5 A 5 ranges: up to 150 µA, 1.5 mA, 15 mA, 150 mA, 1.5 A

Resolution	100 nA
Accuracy	± 0.5 % of full scale ± 0.3 % of reading
Temperature coefficient	± 1 digit / 4 °C between 15 ° and 35 °C
Voltage loss	⩽125 mV for currents ⩽ 100 mA ⩽200 mV for 1 A

4. Alternating currents

Measuring range	0.1 μA ... 1.5 A 5 ranges: up to 150 μA, 1.5 mA, 15 mA, 150 mA, 1.5 A
Resolution	100 nA
Accuracy	± 0.5 % of full scale ± 0.3 % of reading
Frequency range	30 Hz ... 1 kHz
Temperature coefficient	± 1 digit / 3 °C between 15 ° and 35 °C
Voltage loss	⩽125 mV for currents ⩽ 100 mA ⩽200 mV for 1 A

5. Resistances

Measuring range	0.1 Ω ... 15 MΩ 6 ranges: up to 150 Ω, 1.5 kΩ, 15 kΩ, 150 kΩ, 1.5 MΩ, 15 MΩ
Resolution	0.1 Ω
Accuracy	± 1 % of full scale for ranges ⩽ 1.5 MΩ ± 2 % of full scale for range 15 MΩ
Temperature coefficient	± 1 digit/2 °C for ranges ⩽ 150 kΩ ± 2 digits/°C for ranges 1.5 MΩ and 15 MΩ
Test voltage	0.15 V for range 150 Ω; 1.5 V for all other ranges

B. GENERAL DATA

1. Display

Read out	4 digital indicator tubes; maximum read out 1499
Polarity	automatic display of + or -, ~ sign for AC
Decimal point	set automatically by range selector

2. Analog to digital conversion

Conversion system	delta pulse modulation system *
Integration time	20 msec
Sampling rate	1 or 5 times per second, additional hold position to keep the reading displayed
Response time	< 1.5 sec for DC measurements < 3 sec for AC and resistance measurements

* Philips patent

3. Input

Measuring input	floating
Max. common mode signal	500 V d.c. 350 V a.c., 50 Hz
Capacity LOW - ⏚	1.5 nF

4. Temperature range

Ambient temperatures	0 ... + 45 °C
Zero point drift	± 1 digit/4 °C

5. Protection

Maximum permissible voltages

Range	Value
150 mV and 1.5 V DC and AC	350 V d.c.; 300 V a.c. (50 Hz)
ranges > 1.5 V AC	500 V d.c.; 600 V a.c. (50 Hz)
ranges > 1.5 V DC	1.2 kV d.c.; 300 V a.c. (50 Hz)

The voltage ranges are protected for overloads of up to 3 kV supplied by high ohmic sources.

Current ranges	2 A fuse and power diodes for protection of the shunts
Resistance ranges	ranges ≤ 150 kΩ: 20 V d.c., 20 V a.c. (50 Hz) ranges 1.5 MΩ and 15 MΩ: 350 V d.c., 300 V a.c. (50 Hz)

6. Calibration

Calibration voltages	+ 1.100 V and - 1.100 V
Accuracy	± 0.1 %
Temperature coefficient	50 ppm/°C

7. Power supply

Mains voltage	110 V or 220 V, ± 15 % Additional adaption by 18 V is possible
Frequency	50 ... 60 Hz
Power consumption	22 W

C. MECHANICAL DATA

Dimensions	height : 145 mm width : 230 mm depth : 270 mm
Weight	about 6 kg

III. Accessories

Supplied with multimeter

- Set of measuring leads with test pins
- Measuring clip for measuring resistances (see VI. E. 7)
- Interconnection strip between terminals "0" and ⏚
- Mains cable
- Manual

Optionally available

- EHT probe PM 9240

  This probe is suitable for measuring direct voltages up to 30 kV.
  Input resistance: 1000 MΩ ± 5 %
  Maximum error: 5.5 % (including errors of PM 2422)

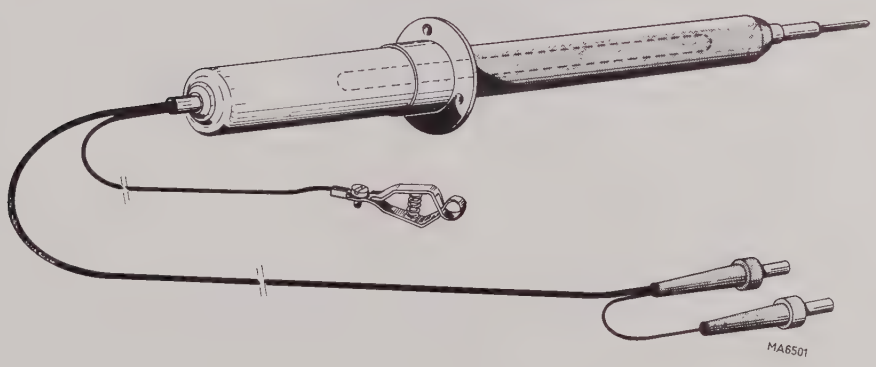


Fig. 1. EHT probe PM 9240

- UHF probe PM 9200

  This probe is suitable for measuring alternating voltages of between 10 mV and 16 V.
  Frequency response: 100 kHz ... 1 MHz ± 10 %
  1 MHz ... 300 MHz ± 5 %
  300 MHz ... 800 MHz ± 10 %
  At frequencies above 30 MHz these tolerances apply only if T-connector PM 9250 is employed.
  The calibration graph supplied with the probe should be observed.
  Maximum permissible direct voltage on the probe: 450 V.
  Input impedance at 1 MHz : 110 kΩ
  10 MHz : 80 kΩ
  50 MHz : 25 kΩ

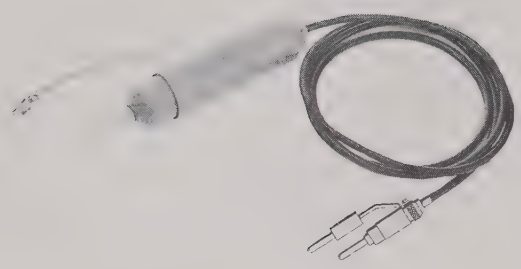


Fig. 2. UHF probe PM 9200

- UHF T-connector PM 9250

Impedance : 50 Ω

Frequency response: 0.1 ... 1000 MHz

Standing wave ratio: for frequencies of up to 800 MHz: 1.1

for frequencies of between 800 MHz and 1000 MHz: 1.2

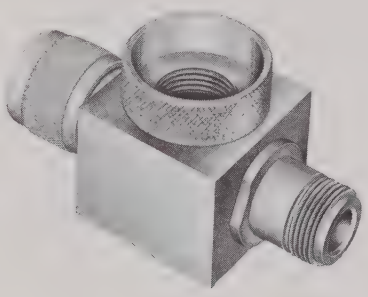


Fig. 3. UHF T-connector PM 9250

- Step-down transformer PM 9052

With this transformer it is possible to measure alternating currents over 3 A up to a maximum of 100 A.

Accuracy: 2 %, including errors of PM 2422

Power: 2.5 VA (secundary voltage at a secondary current of 1 A may be 2.5 V)

Frequency: 30 ... 400 Hz

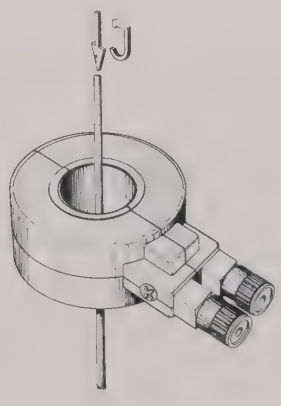


Fig. 4. Step down transformer PM 9052

- Shunt PM 9242

This shunt allows extending the DC and AC current range (at 50 Hz) up to 10 A.
Voltage drop: max. 100 mV
Accuracy : 2 %, including errors of PM 2422
Dimensions : 130 x 65 x 95 mm

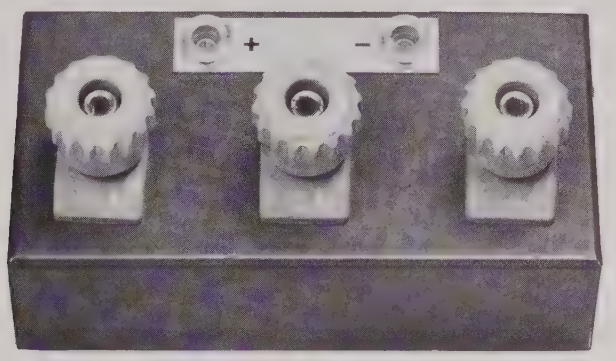


Fig. 5. Shunt PM 9242

IV. Description of the instruments

A. PRINCIPLE OF THE ANALOG-TO-DIGITAL CONVERTER (ADC)

The analog-to-digital converter of the PM 2422 is based on the delta-modulation principle. * This principle ensures good linearity; furthermore the circuit contains a minimum of critical elements

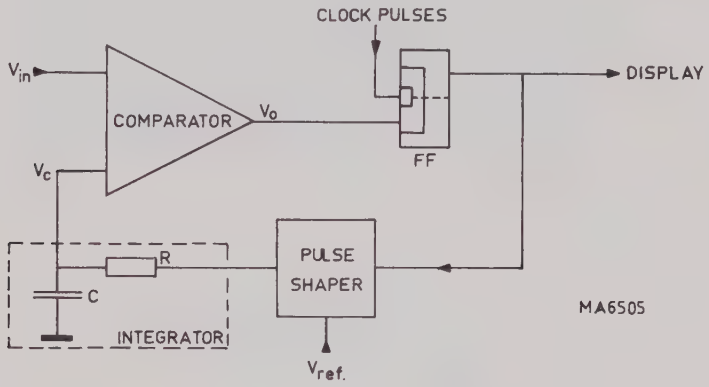


Fig. 6. Basic circuit of the analog-to-digital converter

The basic circuit of the ADC is shown in Figure 6. The operation of the circuit is as follows:
The d.c. signal to be measured (V_{in}) is compared with the voltage across capacitor C (V_c).
The output voltage (V_o) of the comparator activates flip-flop FF if V_o is above a certain level.
The output pulses of FF are supplied to the program circuit and a pulse shaper. The latter shapes the FF-pulses and clips them to an amplitude equal to the reference voltage. These shaped pulses are supplied to the integrator, thus increasing the capacitor voltage (V_c).
Then the value of V_o will decrease to such a level that FF is blocked, resulting in zero level at the input of the integrator. The integrator capacitor will then discharge until $V_{in} > V_c$, whereafter the whole process is repeated.

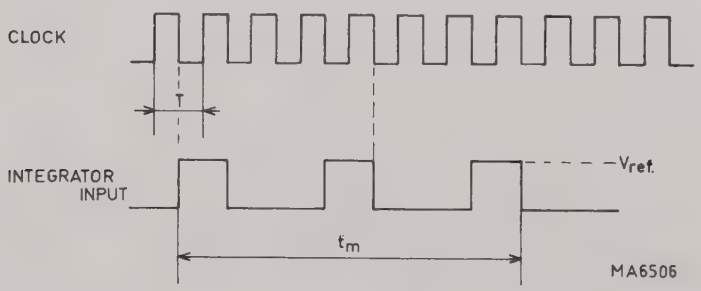


Fig. 7. Pulse diagram

* Patented by J.C. Balder and C. Kramer Philips' Research Laboratories)

Let us suppose, that during the integration time t_m (measuring time), which is equal to N clock pulses, n pulses with a pulse time T are fed into the capacitor. The charge supplied is then:

$$Q_c = nT \frac{V_{ref} - V}{R}$$

The charge drained in the same time period will be:

$$Qd = T\ (N-n) \frac{V_c}{R}$$

where N equals the total number of clock pulses during t_m $(N = \frac{t_m}{T})$

To keep the comparator in balance, Q_c should be equal to Q_d, so that $nT \frac{V_{ref.} - V_c}{R} = T\ (N-n) \frac{V_c}{R}$

given the result $V_c = \frac{n}{N} \cdot V_{ref}$.

If $V_c = V_{in}$, than $\frac{n}{N}$ (the ratio between the number of pulses supplied by FF to the maximum number of pulses to be supplied) is equal to $\frac{V_{in}}{V_{ref}}$

Thus $V_{in} = \frac{n}{N} V_{ref}$.

B. BLOCK DIAGRAM (Fig. 8)

1. Input circuit

The purpose of the input circuit is to supply a d.c. voltage of 150 mV or 1.5 V to the ADC input. A short survey of the circuit arrangements for the various modes of operation is given below.

- Direct voltages at input V are supplied to the DC attenuator (AC/DC switch in position DC) and then passes directly to the ADC.
- Alternating voltages at input V are first attenuated (AC/DC switch in position AC) and then converted into a d.c. voltage which is supplied to the ADC.
- Currents supplied to the input IR are converted into a d.c. voltage by shunt R at the input. This voltage is passed directly to the ADC in case of direct current measurements or to the AC/DC converter in case of alternating current measurements.
- For resistances a constant direct current is passed through the unknown resistor connected to input IR. This current is obtained in two ways.
  For the ranges $\leq$100 kΩ the selector is in position R<, so that a constant current is provided by the 80 V supply and a large series resistor. The voltage across the unknown resistor is supplied to the ADC.
  For the ranges 1 MΩ and 10 MΩ a constant current is derived from the ADC. This current is supplied to the unknown resistor (selector in position R>) and causes a voltage drop which is fed to the ADC.

2. ADC

Conversion from a d.c. level to a proportional number of pulses is effected with a bipolar ADC. The principle of this ADC has been described in Section IV.A. However, to permit of measuring positive as well as negative voltage levels a positive and negative reference voltage is necessary. At full scale (1500) the ADC supplies pulses to the program circuit with a frequency which is equal to half the clock frequency.

3. Program unit

The program controls the measuring sequence. A 1-Hz-generator supplies a start pulse, which
- starts the timer; this determines the integration period of 20 msec. by counting clock pulses.
- sets the polarity by activating a polarity flip-flop and so selects the positive or negative reference voltage in the ADC.

4. Display unit

The display counts the number of incoming ADC pulses, which are proportional to the input voltage. The number of pulses are indicated by numerical indicator tubes.

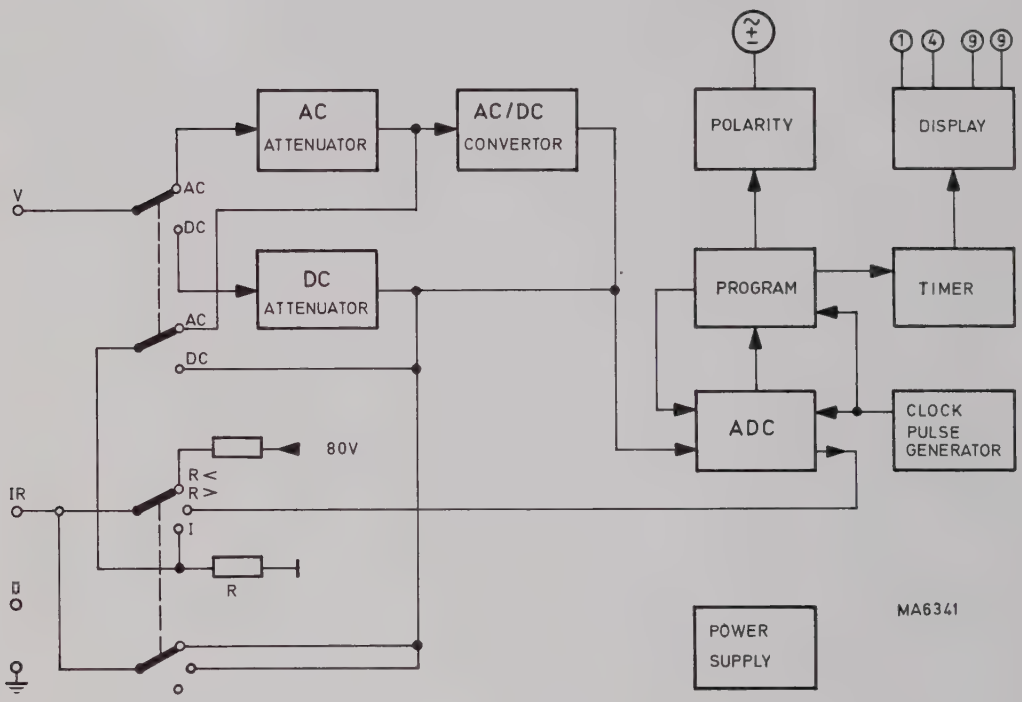


Fig. 8. Block diagram

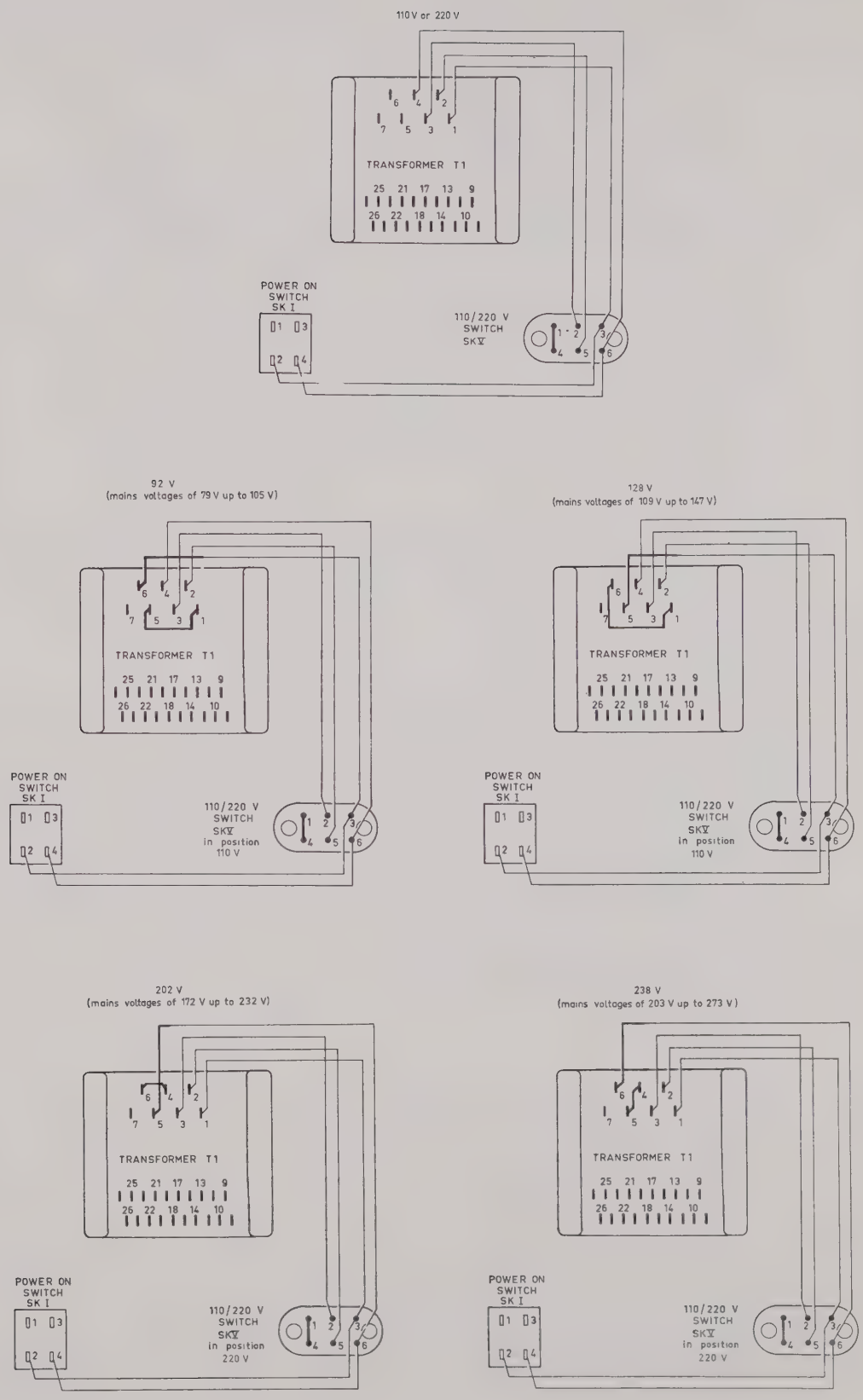

110 V or 220 V
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
6 4 2
7 5 3 1
POWER ON SWITCH SK I
1 3
2 4
110/220 V SWITCH SK V
92 V
(mains voltages of 79 V up to 105 V)
110/220 V SWITCH SK V in position 110 V
128 V
(mains voltages of 109 V up to 147 V)
202 V
(mains voltages of 172 V up to 232 V)
110/220 V SWITCH SK V in position 220 V
238 V
(mains voltages of 203 V up to 273 V)

Fig. 9. Adaptation of the mains transformer

V. Installation

A. MAINS SUPPLY

Before the instrument is connected to the mains it is necessary to check that the setting of sliding switch SKV at the rear corresponds to the value of the local mains voltage.

- Mains voltages between 95 V and 125 V: set sliding switch to 110 V.
- Mains voltages between 187 V and 253 V: set sliding switch to 220 V.

The rating of fuse VL2 at the rear should be 400 mA, delayed action, for 220 V mains, and 800 mA, delayed action, for 110 V mains.

Connection

The instrument should be connected to a wall socket with rim earthing contacts by means of the three-core lead supplied with the multimeter.

Adaption of the mains transformer

The mains transformer has an additional winding which can be used to adapt the instrument to a mains voltage which is 18 V higher or lower than the nominal voltage (110 V or 220 V).
Fig. 9 gives the adaption possibilities for the various voltages.

B. EARTHING

The instrument should be connected to a wall socket with rim earthing. For safety reasons the instrument housing is connected to earth.
If it is not possible to earth the instrument via the mains cable the instrument should be earthed via the earthing screw (⏚) at the rear of the instrument.
Moreover local safety regulations must be observed.

C. COMBINING THE INSTRUMENT WITH OTHER MODULES

The chassis of the PM 2422 may be accommodated in a 6-module cabinet PM 9706 instead of the 3-module cabinet. The additional space in this cabinet can be used for other units of the 3E modular system, which may be employed in conjunction with a digital voltmeter or independently.
This 6-module cabinet is suitable for mounting in 19" racks. If the additional space is not used, it can be closed off by means of a blank panel PM 9723.
For converting the instrument into the rack-mounting version, proceed as follows:

- Remove the grey plastic cable cover from the PM 9706 cabinet and take out the brackets
- Remove the four screws at the two sides
- Slightly lift the side plates at the front and remove the plastic plates which are now accessible. The brackets can now be placed in the free space.
- Refit the side plates and secure them with the four screws
- Remove the four feet
- Mount the desired number of guide rails to the upper and lower crossbars. The appropriate holes in the crossbars are threaded
- Slide the PM 2422 out of the 3-module cabinet and into the 6-module cabinet
- Fill the free space with panel PM 9723
- Lock the PM 2422 and PM 9723.

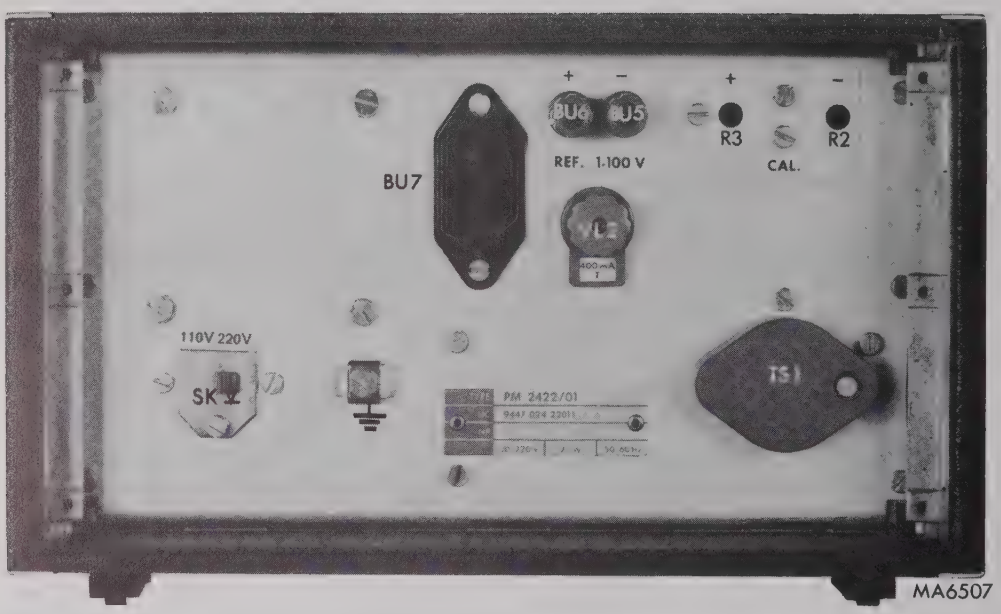


Fig. 10. Rear view

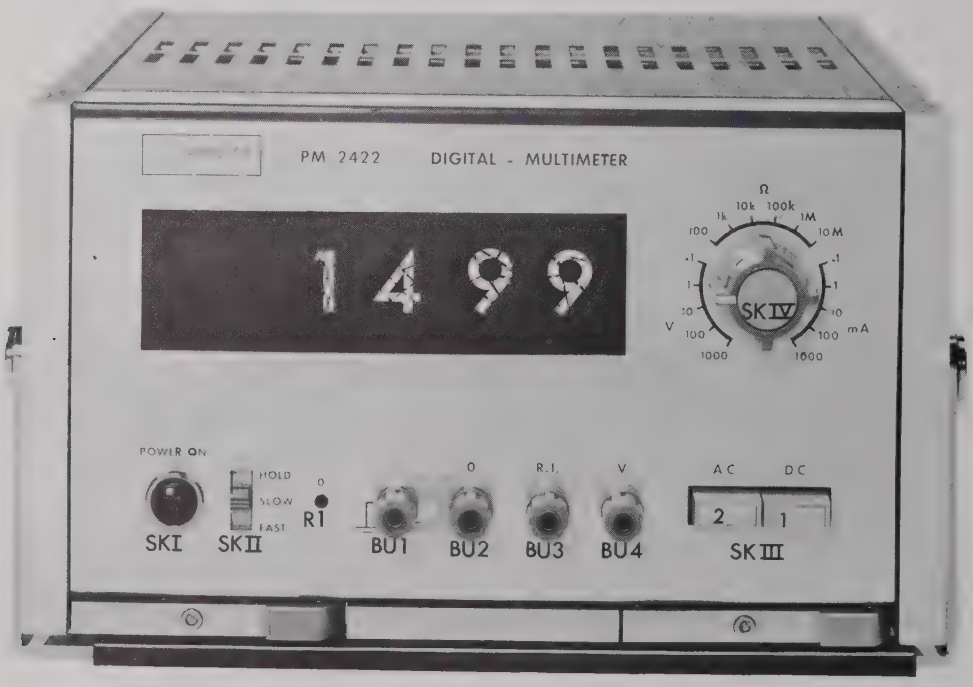


Fig. 11. Front view

VI. Operation

A. SWITCHING-ON

The instrument is ready for operation after connection to the mains and earthing. It is switched on by means of mains switch POWER ON (SKI); then the display tubes light up.
A warming up time of approx. 20 minutes should be observed for obtaining full accuracy.

B. SAMPLING RATE

The number of measurements in one second can be adjusted with slide switch SKII, which offers the following possibilities:

- FAST : 5 measurements per second
- SLOW : 1 measurement per second
- HOLD : the reading is maintained until the switch is set to position FAST or SLOW

C. ELECTRICAL ZERO SETTING

- Switch on the instrument
- Interconnect terminals "0" (BU2) and V (BU4)
- Press push button DC (SKIII/1)
- Set range selector SKIV to position .1 V
- Adjust the reading to .0000 by means of potentiometer 0 (R1, screwdriver adjustment at the front)
- If the indicators "+"/"-" light up alternately, this is an indication that the zero setting has been effected accurately.

D. CALIBRATION

- Press push button DC (SKIII/1)
- Set range selector SKIV to position 1 V
- Interconnect terminals V (BU4, front) and + REF. 1.100 V (BU6, rear)
- Adjust the reading to 1.100 with potentiometer + CAL (R3, screwdriver adjustment at the rear). Polarity: +
- Interconnect terminals V (BU4, front) and - REF. 1.100 V (BU5, rear)
- Adjust the reading to 1.100 with potentiometer - CAL (R2, screwdriver adjustment at the rear). Polarity: -

E. MEASURING

Checking the zero setting and the calibration is only necessary in case of important temperature variations.

1. Direct and alternating voltages

- Select measuring mode DC or AC
- Connect the voltage to be measured to terminals "0" (BU2) and V (BU4)
- Select the correct measuring range with the range selector (SKIV)

Notes

- For practically all measurements, terminals ⏚ (BU1) and "0" (BU2) can be interconnected with the interconnection strip included in delivery. For floating measurements this strip must be removed.
- The capacitance between terminals ⏚ (BU1) and "0" (BU2) is 1.5 nF
- For d.c. voltages the polarity indicator indicates the polarity on terminal V with respect to terminal "0".
  For a.c. voltages the indicator shows "~"
- Maximum permissible voltage between terminal "0" and chassis (⏚) is 500 V d.c. or 350 V a.c. (50 Hz)
- Maximum permissible measuring voltages

Range	Measuring mode DC	Measuring mode AC
150 mV 1.5 V	350 V d.c.; 300 V a.c. (50 Hz)	350 V d.c.; 300 V a.c. (50 Hz)
15 V 150 V 1 kV	1.2 kV d.c.; 300 V a.c. (50 Hz)	500 V d.c.; 600 V a.c.

- DC voltages over 1000 V and up to 30 kV can be measured with EHT measuring probe PM 9240 (point 2)
- UHF voltages should be measured with probe PM 9200 and T-connector PM 9250 (point 3)

2. EHT voltages up to 30 kV with probe PM 9240

- Select measuring mode DC
- Connect the probe to terminals "0" and V (terminals "0" and ⏚ should be interconnect by the interconnection strip)
- Connect the earthing clip of the probe to a proper earth
- With the range selector the following measuring ranges are possible:

Range selector to position	HT range
100 V	10 kV
1000 V	100 kV (see note)

Note

- Maximum permissible d.c. voltage 30 kV
- The position of the decimal point should be observed.

3. UHF voltages (with probe PM 9200 and T-connector PM 9250)

- Select measuring mode DC
- Connect the probe-plug to terminals "0" and V, with the earthing pin of the probe to terminal "0" (terminals "0" and ⏚ should be interconnected)
- Set the measuring range selector to the desired position.

Note

- The maximum permissible voltage on the probe is 16 V r.m.s.
- The correction factor on the calibration curve of the probe should be taken into account.

4. DC and AC currents

- Select measuring mode DC or AC
- Connect the current source to be measured to terminals "0" and R.I. (BU3)
- Select correct measuring range with selector SKIV

Notes

- For d.c. currents the polarity indicator shows the polarity at terminal R.I. with respect to terminal "0".
  For a.c. currents the indicator shows " ~ ".
- Maximum permissible current in all ranges: 2A
- In the current circuit a 2-A fuse (VL201; fast) has been incorporated to protect the shunt resistors (R2050 ... R2053) against overloads. The fuse is fitted in an open fuse holder, mounted on printed wiring board U2 (for replacement of the fuse see IX.D.a.)
- D.C. currents over 1 A and up to 10 A can be measured with DC shunt PM 9242 (point 5)
- AC currents over 1 A and up to 100 A can be measured with current transformer PM 9052 (point 6)

5. DC current measurements with DC shunt PM 9242

- Select measuring mode DC
- Connect the output sockets + and - of shunt PM 9242 to terminals "0" and V
- Set the range selector to position .1 V
- Connect the current source to terminals - and 10 A of the PM 9242 (for 10 A max.)

Note

- As the range selector is set to position .1 V, the measuring result should be multiplied by 100 to find the correct current value
- Maximum permissible direct current 10 A
- Shunt PM 9242 has also a range of max. 30 A. At 33.3 A the output voltage is 100 mV exactly.

6. AC current measurements with current transformer PM 9052

- Select measuring mode AC
- Connect the terminals of transformer PM 9052 to terminals "0" and R.I.
- Set the range selector to position 1000 mA
- Pass the current-carrying conductor through the opening of the transformer

Note

- Maximum permissible alternating current 100 A

7. Resistors

- Push buttons DC and AC not depressed
- Connect the unknown resistor to terminals "0" and R.I.
- Select correct measuring range

Notes

- The test voltage at terminal R.I. is 0.15 V for the 150-Ω-range and 1.5 V for all the other ranges
- For measuring resistors the measuring clip, included in delivery, can be used

- Protection:

Range	Max. permissible voltage
150 Ω 1.5 kΩ 15 kΩ 150 kΩ	20 V d.c. and 20 V a.c. (50 Hz)
1.5 MΩ 15 MΩ	350 d.c. and 300 V a.c. (50 Hz)

VII. Circuit description

GENERAL

In principle the circuit can be differentiated into the following:

A. Power supply

B. Analog part or input circuit

C. Digital part

A. POWER SUPPLY (Fig. 12)

1. Transformer

Primary

The primary windings S1 and S1' of transformer T1 can be connected in series (for 220 V mains) or in parallel (for 110 V mains) with switch SKV.
If the nominal voltage deviates from these values adaption is possible with S1'' (18 V).

Secondary

The secondary windings S2, S2', S3, S3' and S4 supply the AC voltages for the rectifying circuits. These circuits deliver a non-stabilised voltage of +220 V and 7 stabilised voltages (+80 V, -80 V, +15 V, -15 V, +6 V, +1.100 V and -1.100 V)

2. Voltage source +220 V

The voltage of +220 V is used for the digital indicator tubes and is obtained from full wave rectifier GR220. C220 servies for smoothing.

3. Voltage sources +80 V and -80 V

The secondary voltage of windings S2 and S2' is approx. 165 $V_{r.m.s.}$, which is rectified with bridge-rectifier GR220 and smoothed by capacitors C220 and C222. After the rectifier the circuit is divided into a positive and a negative circuit with common zero. Since the stabilisation circuits for positive and negative voltages are symmetrical with respect to zero, only the positive circuit will be described in detail. The parts shown between brackets refer to the negative stabilisation circuit.
The first voltage stabilisation is obtained by R2090 and GR221 + GR222 (R2102 and GR225 + GR226). This circuit is followed by a constant current source with TS220 and GR223 (TS221 and GR227). The current can be adjusted by resistor R2093 (R2104). As the load of the +80 V (-80 V) supply is constant, the current through stabilising tube B201 (B202) is constant.
In order to ensure proper ignition of B201 (B202) the -80 V (+80 V) supply is used. Ignition of the tube requires about 120 V. Suppose that B201 (B202) is extinguished. At the anode of B201 (B202) there will be 100 V. Diode GR228 (GR224) is cut off, so the cathode of B201 (B202) is connected to the -80 V (+80 V) supply via resistor R2096 (R2107).
Under these conditons, the total voltage across B201 (B202) is 180 V, which is enough to ensure ignition. After ignition, diode GR228 (GR224) will become conductive.
The output voltage can be adjusted with R2097 (R2110) to +79.7 V $\pm$ 150 mV (-79.7 V $\pm$ 150 mV). R2095 and C221 (R2108 and C223) serve to hold the burning voltage at the correct value.

4. Voltage sources +1.100 V and -1.100 V

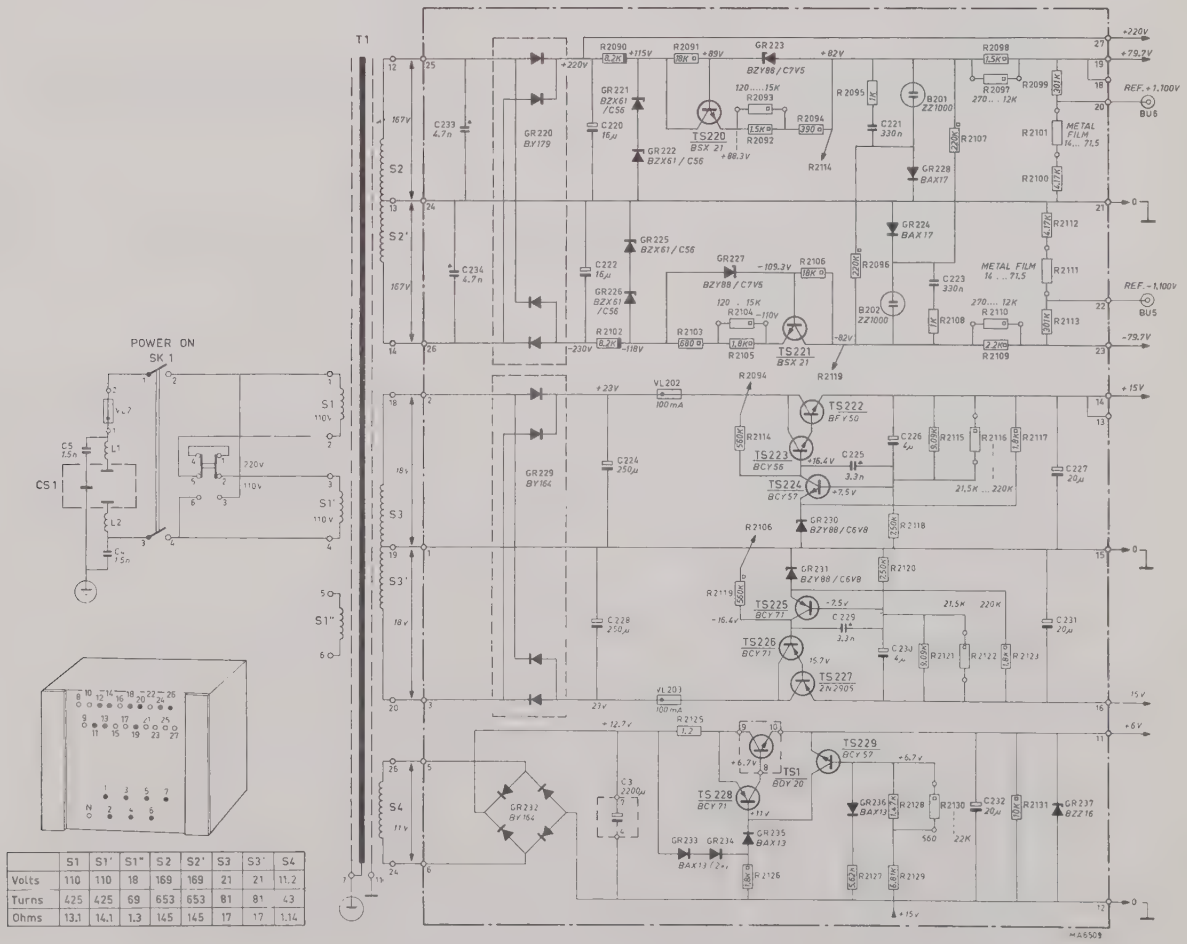
These voltages are derived from the +80 V and -80 V supply by a voltage divider. The voltage is adjusted with R2101 and R2111 to ± 0.1 %.

5. Voltage sources +15 V and -15 V

These voltage sources are used for the amplifiers in the AC to DC converter and the analog to digital converter. The voltages are obtained from windings S3 and S3'. Stabilisation is effected in the conventional way (series stabilisation). The output voltages are adjustable with R2116 (+15 V) and R2122 (-15 V).

6. Voltage source +6 V

This voltage is required for the integrated circuits. The reference voltage for the +6 V supply is derived from the +15 V source.
In the event of a short-circuit the voltage drop across R2125 exceeds the threshold voltage of GR235, the current through TS1 and TS228 thus being limited. Moreover, an additonal zener diode GR237, with a zener voltage of 6.9 V, is circuited at the output of the +6 V supply, the integrated circuits thus being protected against excess voltages. The output voltage can be adjusted with R2130.



	S1	S1'	S1''	S2	S2'	S3	S3'	S4
Volts	110	110	18	169	169	21	21	11.2
Turns	425	425	69	653	653	81	81	43
Ohms	13.1	14.1	1.3	145	145	17	17	1.14

Fig. 12. Power supply

B. ANALOG SECTION OR INPUT CIRCUIT

The analog part of the instrument serves to convert the input signal into a d.c. signal of 150 mV or 1.5 V for full scale. This signal is supplied to the ADC input.

1. DC voltage circuit

The input circuit for d.c. measurements is shown in Figure 13. The attenuation for the various ranges is given in the table below.

Range	Attenuation
.1 V	1
1 V	1
10 V	10
100 V	100
1000 V	1000

Spark gap VL1, which will conduct at voltages over 1700 V, serves to protect switch SKIV/1 and the attenuator resistors.

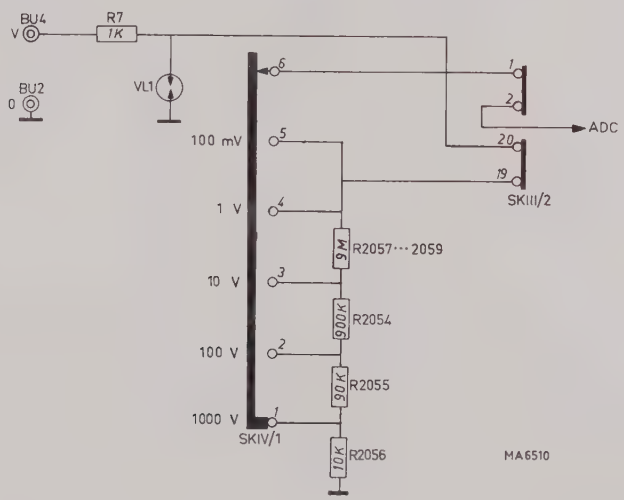


Fig. 13. DC voltage circuit

2. AC voltage circuit (Fig. 14)

The input signal is supplied to a frequency independent attenuator via SKIII/2 (AC mode selector) and C309.

The attenuation for the various ranges is given in the table below.

Range	Attenuation
.1 V	1
1 V	1
10 V	100
100 V	100
1000 V	1000

The attenuated a.c. signal is supplied to the AC/DC converter, which converts the a.c. signal into a d.c. signal.

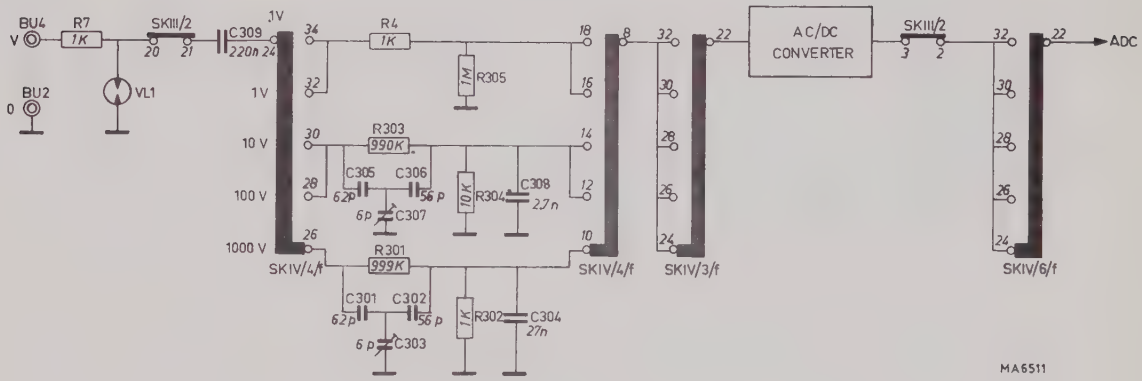


Fig. 14. AC voltage circuit

3. Direct and alternating current circuit (Fig. 15)

Currents are converted into voltages by means of shunt-resistors R2050...R2053. The voltage across the selected shunt amounts to 150 mV for full scale.

For direct current, the direct voltage across the shunt is supplied directly to the ADC via SKIII/2.

For alternating current the voltage across the shunt is supplied to the AC/DC converter via C310 and SKIV/3/f. The output direct voltage of the AC/DC converter is supplied to the ADC via SKIII/2.

4. Circuit for resistance measurements (Fig. 16)

For resistance measurements two circuits are used, one for ranges 100 Ω, 1 kΩ, 10 kΩ and 100 kΩ, and the other for ranges 1 MΩ and 10 MΩ.

For the ranges $\leq$ 100 kΩ the supply voltage of +79.7 V is used in combination with a large resistor. This results in a constant current through the resistance to be measured (Rx). The voltage drop across Rx is supplied to the ADC (0.15 V for range 100 Ω, 1.5 V for the ranges 1 kΩ, 10 kΩ and 100 kΩ). To limit the voltage at terminal R (BU3) to about 3 V a limiting circuit consisting of GR210 ... GR212/R2080/R2081 is used.

For the ranges 1 MΩ and 10 MΩ a simplified diagram is given in Fig. 17.

If the circuit is in balance $V_{ref.}$ is equal to V_{Rx}. So the voltage between points P and Q is zero. Hence the voltage drop across R_B will always be V_z, and a constant current passes both R_B and R_X. The resulting voltage drop across R_x is supplied to the analog-to-digital converter.

R_A consists of R3/R129/R130, and R_B of R131/R2068... R2072 (for range 1 MΩ) or R131/R2068.. ...R2072/R2060...R2067 (for range 10 MΩ).

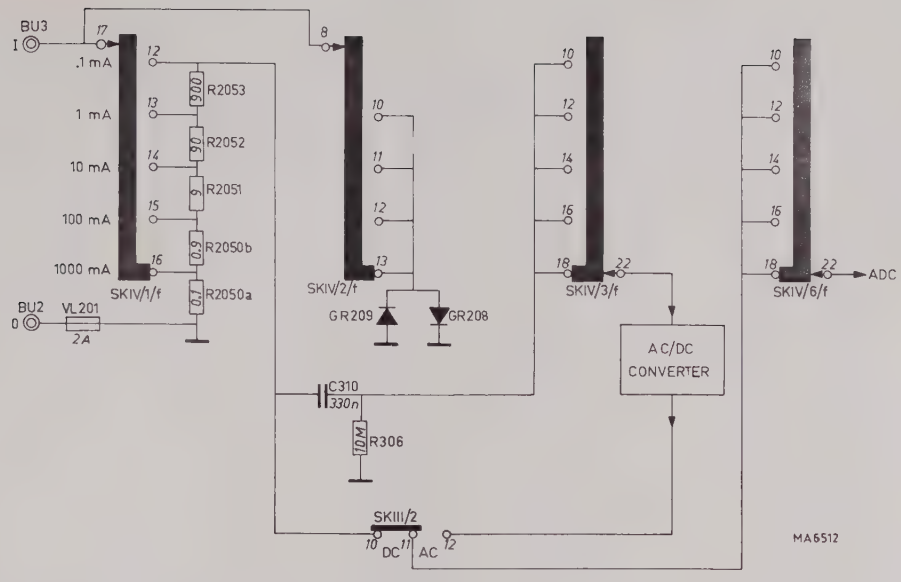


Fig. 15. Direct and alternating current circuit

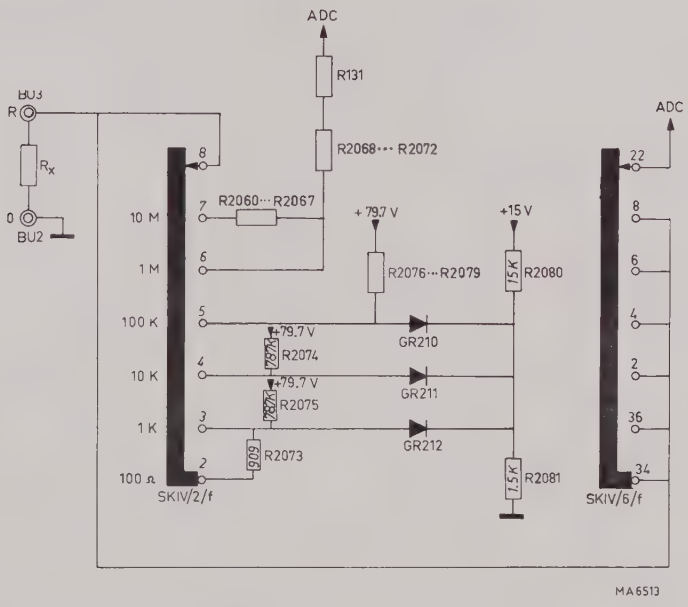


Fig. 16. Circuit for resistance measurements ($\leq$ 100 kΩ)

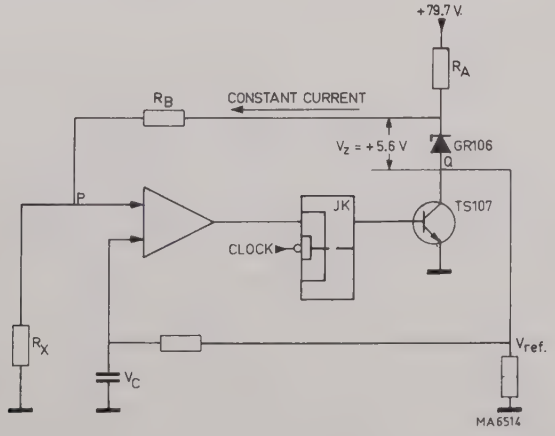


Fig. 17. Circuit for resistance measurements (1 MΩ and 10 MΩ)

5. AC/DC converter (Fig. 19)

The converter serves to convert the supplied a.c. voltage into the d.c. voltage necessary for the analog-to-digital converter.

The input voltage of the converter for the various ranges is as follows (see B.2.):

Range	Input
150 mV	150 mV
1.5 V	1.5 V
15 V	150 mV
150 V	1.5 V
1.5 kV*	1.5 V
current ranges	150 mV

The converter consists of an amplifier, a rectifier and a d.c. feed-back circuit.

Amplifier

The amplifier consists of TS201...TS206, with two FET's in the input (TS201, TS202). TS203 serves as constant current source. GR201 and GR202 limit the input signal to + or -15 V.
The output voltage is fed back to the input via a voltage divider. The amplification of this stage is determined by: $\frac{R2018 + R2019}{R2019}$. For the ranges 150 mV and 15 V resistors R2013//R2014// R2015 are placed in parallel to R2019 in order to give a higher amplification.

Rectifier

A simplified diagram of the rectifier is shown in Fig. 18.

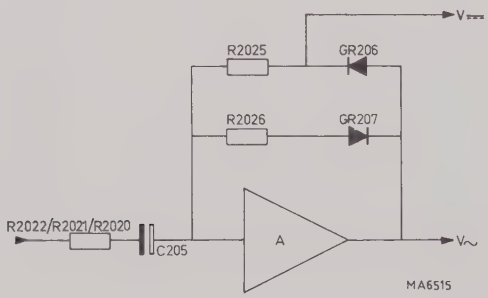


Fig. 18. Rectifier

The amplifier A consists of TS207...TS209.
The amplification of the amplifier amounts to $\frac{R2025 \text{ (or } R2026)}{R2020/R2021/R2022}$ (approx 1).
The a.c. output voltage of the amplifier is rectified by diodes GR206 and GR207. The d.c. output voltage (half-wave rectified) is always +1.5 V and is connected to the ADC via a low-pass filter. Capacitor C205 blocks the d.c. signal from the preceding amplifier.

* In this range max. 600 V admissible.

DC feedback

The a.c. output voltage V ~ of Fig. 18 is used for stabilisation of the rectifier circuit. The larger part of this signal is drained off via R2045 and C212. The remaining AC signal is supplied to the bases of difference amplifier TS211 (common mode signal). In this way a d.c. feedback occurs via TS211. TS210 is a constant current source for the amplifier.
Potentiometer R2043 serves to adjust the output to zero level if there is no input signal.

Survey of voltage levels (full scale values)

Range	Input AC/DC converter	Output amplifier	Output converter
100 mV	100 mV	2.22 V	1 V
1 V	1 V	2.22 V	1 V
10 V	100 mV	2.22 V	1 V
100 V	1 V	2.22 V	1 V
1000 V	1 V	2.22 V	1 V
current	100 mV	2.22 V	1 V

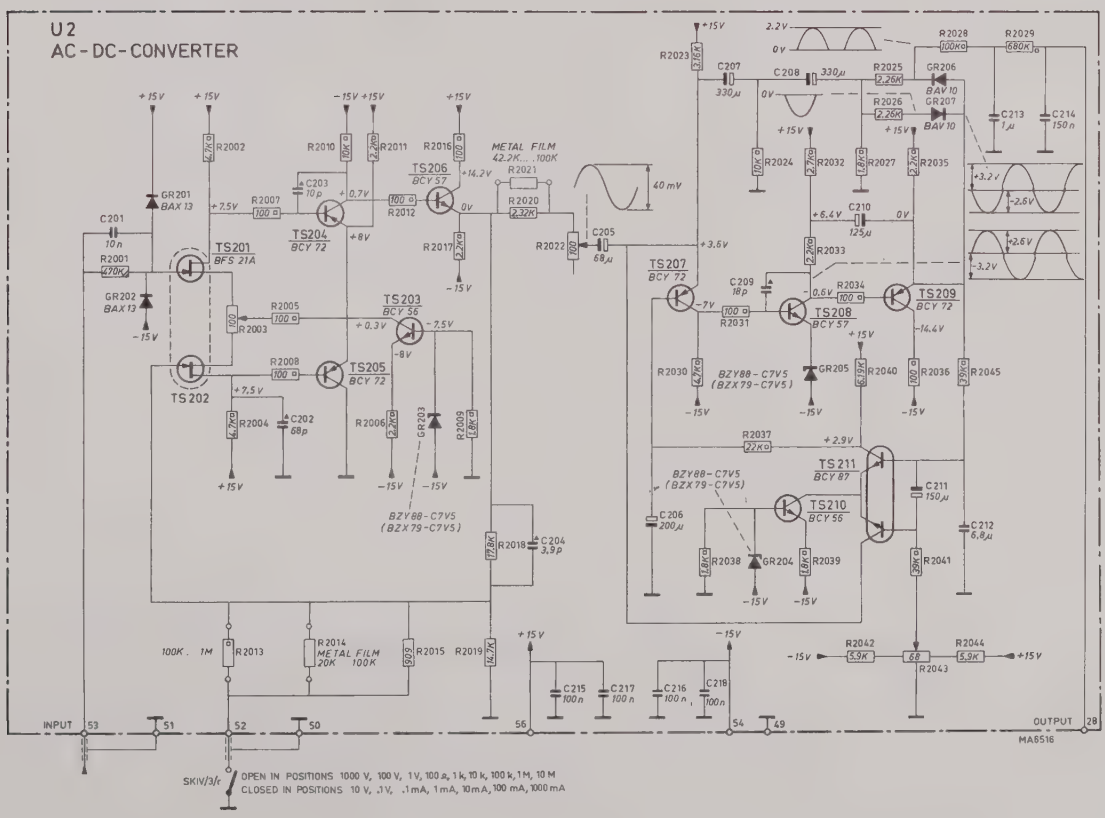

U2
AC-DC-CONVERTER
INPUT
OUTPUT
MA8516
OPEN IN POSITIONS 1000 V, 100 V, 1 V, 100 a, 1 k, 10 k, 100 k, 1 M, 10 M
CLOSED IN POSITIONS 10 V, .1 V, .1 mA, 1 mA, 10 mA, 100 mA, 1000 mA

Fig. 19. AC-DC converter

C. DIGITAL SECTION

1. Analog digital converter (ADC)

The principle of the ADC used has been described in chapter IV.A. However, to measure signals of positive as well as negative polarity, two reference sources and an additional circuit for the selection of the right polarity are necessary. In this way a "bipolar" ADC is obtained.

Fig. 20 shows a simplified diagram of the bipolar ADC.

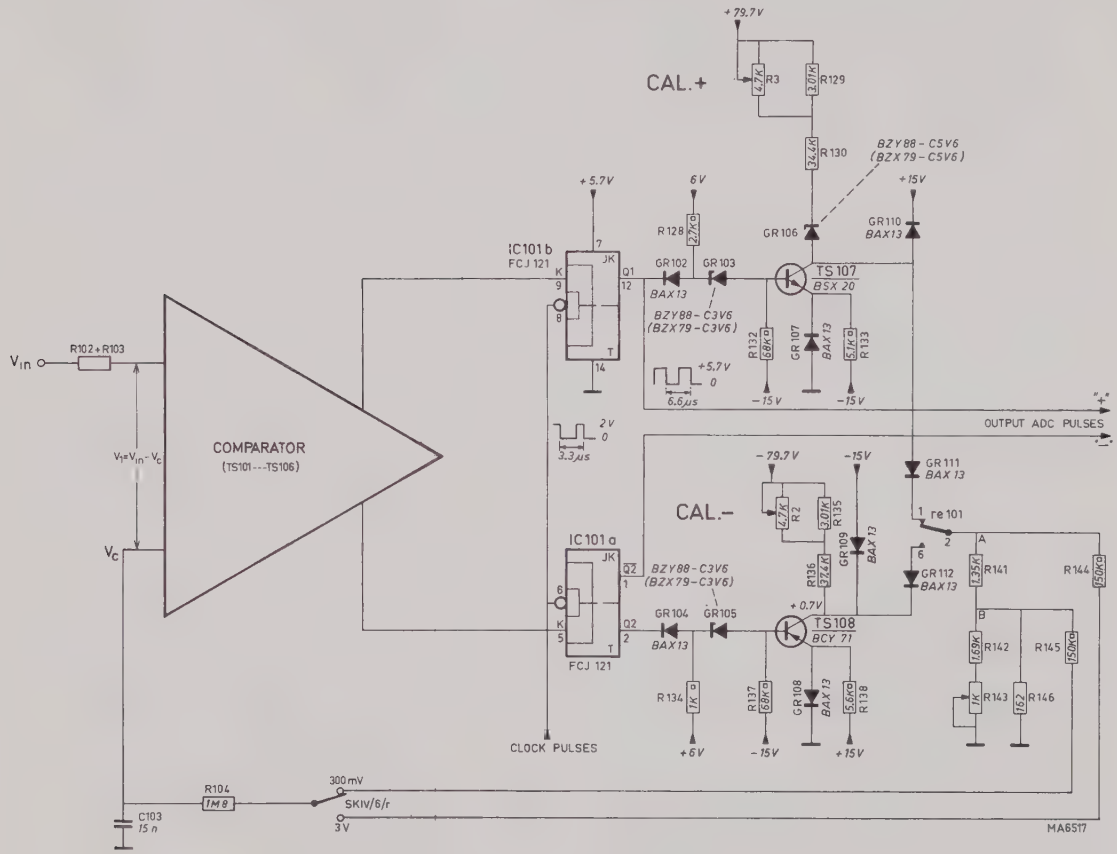


Fig. 20. Simplified diagram of the bipolar analog-to-digital converter

The compator, consisting of transistors TS101 ... TS106, activates IC101b for positive input signals and IC101a for negative input signals. Suppose that the input signal is negative. Input K of IC101b is 0, resulting in a zero level of output Q1. However, input K of IC101q is 1, so IC101a functions as divider of two for the clock pulses. These pulses are applied via diodes GR104 and GR105 to the base of TS108. This transistor is cut off if the output level is 0, and is conductive if the output level is 1. Under these conditions, pulses with an amplitude of -3 V and -300 mV appear at points A and B, respectively. These reference pulses are applied to the integrator R104/C105 via the range selector, which determines if the -3 V or -300 mV pulses are selected. If V_c becomes larger than the input voltage, IC101a will be blocked and IC101b will pass the clock pulses. However the polarity switch is in the "-" position, in consequence of which the pulses have no influence. Points A and B are at zero potential, resulting in a discharging of capacitor C105.

Survey

Selected range		Input voltage ADC	Amplitude of reference voltage pulse
.1 V	DC	0.1 V	0.3 V
1 V	DC	1 V	3 V
10 V	DC	1 V	3 V
100 V	DC	1 V	3 V
1000 V	DC	1 V	3 V
.1 V	AC	1 V	3 V
1 V	AC	1 V	3 V
10 V	AC	1 V	3 V
100 V	AC	1 V	3 V
1000 V	AC	1 V	3 V
100 Ω		0.1 V	0.3 V
1 kΩ		1 V	3 V
10 kΩ		1 V	3 V
100 kΩ		1 V	3 V
1 MΩ		1 V	3 V
10 MΩ		1 V	3 V
.1 mA	DC	0.1 V	0.3 V
1 mA	DC	0.1 V	0.3 V
10 mA	DC	0.1 V	0.3 V
100 mA	DC	0.1 V	0.3 V
1000 mA	DC	0.1 V	0.3 V
.1 mA	AC	1 V	3 V
1 mA	AC	1 V	3 V
10 mA	AC	1 V	3 V
100 mA	AC	1 V	3 V
1000 mA	AC	1 V	3 V

The position of the polarity switch is determined by the polarity selector (see point c)

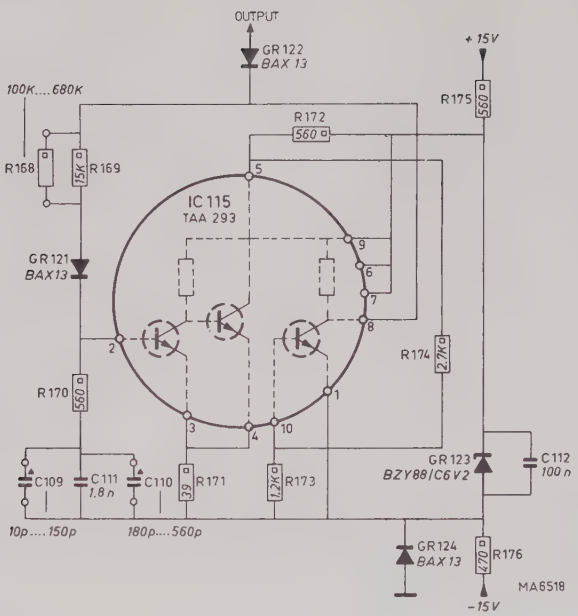


Fig. 21. Clock oscillator

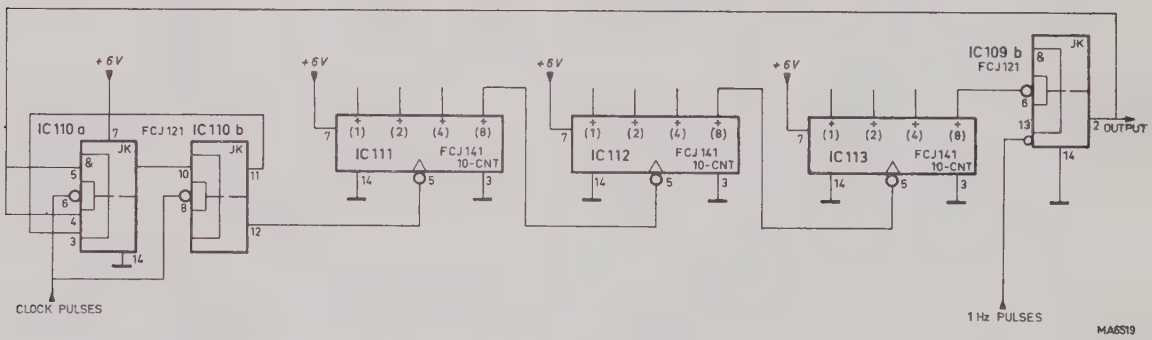


Fig. 22. Timer

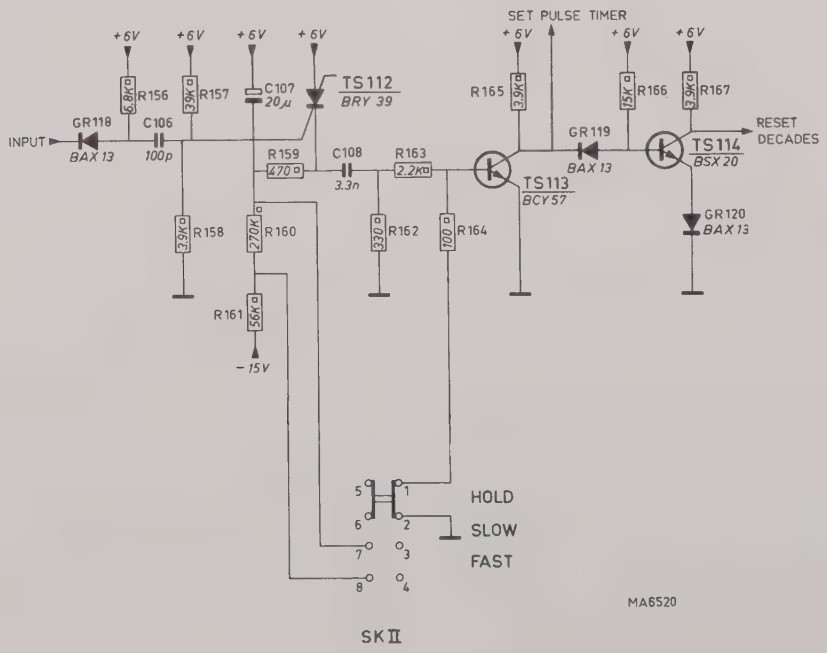


Fig. 23. 1 Hz generator

2. Program

The program makes use of the following circuits: clock oscillator, timer, 1 Hz generator, pulse detector and polarity circuit.
These circuit are described in detail first after which the complete program process is descussed.

a. Clock oscillator (Fig. 21)

The clock pulses are derived from an astable multivibrator.
The output of the amplifier (8) is fed back to the input (2) via resistors R168/R169-GR121 and R170/C109...C111. In this way the voltage operated Schmitt trigger is converted into an astable multivibrator. The frequency is determined by R168/R169/R170 and C109/C110/C111.

b. Timer (Fig. 22)

The timer consists of flip-flops IC110a and IC110b as a scaler of three followed by three decade counters IC111...IC113.
As long as the output of IC109b is 1, gate IC102b is open and pulses from the ADC can pass to the display.
When the timer has counted 3000 clock pulses, however, the output of IC109b becomes 0, gate IC102b and flip-flop IC110a thus being blocked.
Flip-flop IC109b is set to 1 again and the next measurement thus initiated by the next pulse from the 1-Hz generator.
Gate IC102d blocks the timer if no pulses from the ADC are applied to the pulse detector.

c. 1 Hz Generator (Fig. 23)

There are two situations, namely, the presence or the absence at the input of pulses from the ADC.

Absence of pulses

Suppose that C107 has discharged. The cathode of silicon-controlled switch TS112 will be positive with respect to its gate, TS112 thus being cut off. C107 will be charged via R160 + R161 (SK2 in position SLOW) or via R161 (SK2 in position FAST). When the cathode is at about -0.6 V with respect to the gate, TS112 starts conducting and discharges C107 via R159. The pulse width is determined by R162 and C108. The base of TS113 becomes positive, TS113 thus becoming conductive. The output is then 0.
If C107 has discharged sufficiently, TS112 blocks. TS113 also blocks, resulting in output state 1. The repetition frequency of the output pulses is 1 Hz if SK2 is in position SLOW, and 5 Hz with SK2 in position FAST.

Presence of pulses

The discharge time of C107 should be synchronised. This is achieved with C106, which ensures that the discharging of C107 starts at the front edge of an ADC pulse applied to GR118.

If SK2 is in position HOLD, the output of the generator stays in the 1-state.

d. Pulse detector (Fig. 24)

The pulse detector serves to prepare the selection of the polarity. If no ADC pulses are present the silicon-controlled rectifier TS110, and consequently TS111, are cut off and the output state is 1.

If an ADC pulse is applied, TS110 becomes conductive and C104 discharges via R151. Junction R153-C104-TS110 tends to +6 V. TS111 thus becomes conductive and the output is in 0-state.
If ADC pulses are applied continuously, TS110 alternates between conduction and non-conduction but the base of TS111 remains positive. Hence TS111 is conducting and the output state remains 0.
Immediately ADC pulses cease, the oscillation of TS110 stops and junction TS110-C104-R153 tends to zero. TS111 is cut off, the output state being 1.

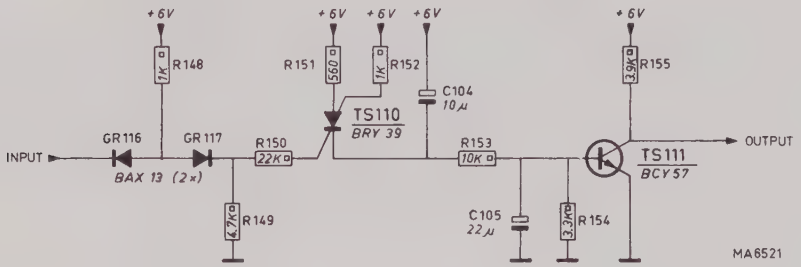


Fig. 24. Pulse detector

e. Polarity circuit (Fig. 25)

As long as no input voltage is applied, the ADC does not supply ADC pulses. This results in a 1-level output of the pulse detector. The output of the pulse detector is connected to the J and K input of polarity flip-flop IC114.
If the J and K inputs are 1, IC114 changes state at every pulse from the 1 Hz generator, resulting in: 1. Alternation of the polarity indication.
2. Switching of the polarity relay in the ADC.
Let us suppose now that a positive voltage is connected to the instrument. The "+" pulses from the ADC will supply pulses to Nand gate IC102c. Only if the second input (IC102c/12), the level of which is determined by polarity flip-flop IC114 (Q), is 1 the ADC pulses will pass IC102c.
If the level is 0 the ADC pulses are blocked. Thus the pulse detector output remains 1, and with the next pulse from the 1 Hz generator IC114 is set to Q = 0, Q = 1. The ADC pulses can then pass IC102c and are supplied to:
1. Nand gate IC102b (see point 3, display)
2. The pulse detector (see point C.2.d.).
The output of the pulse detector becomes 0 and blocks IC114, and so the polarity indication cannot change during the measurement.
The working for negative voltage is in principle the same. The "-" pulses from the ADC are supplied to IC102a/2. The level of the second input (IC102a/3) is determined by output Q of IC114. This output also controls the polarity selector, RE101, via transistor TS109. If output Q of IC114 is 0, transistor TS109 is cut off. RE101 is thus in its rest position and re101 (the relay contact) interconnects the positive reference pulses with the integrator. If output Q of IC114 is 1, transistor TS109 is conducting. Relay contact re101 switches and interconnects the negative reference pulses with the integrator.

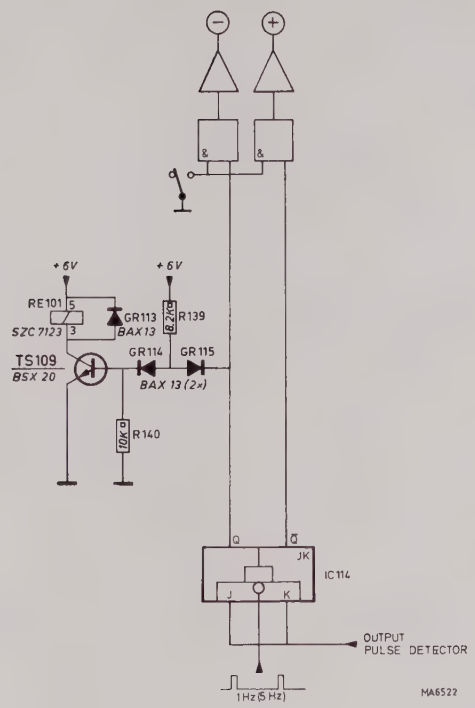


Fig. 25. Polarity circuit

f. Program process (Fig. 26-28)

The measurement is started with every negative pulse of the 1 Hz generator. First the correct polarity is selected. If the polarity is wrong, IC102b blocks the clock pulses, this because IC102b/6 is kept to 0-level by the inverted 1 level of the pulse detector. As soon as the polarity is correct, IC102a or IC102c, depending on the polarity, will supply ADC pulses by which the pulse detector output assumes 0 level. Since, however, the pulse detector gives some delay, the 0-level at IC102b/6 is hold and the input of the timer remains blocked. With the next 1 Hz pulse, start-stop flip-flop IC109b is set to Q = 0. IC102 is blocked.
This process is repeated after every pulse from the 1 Hz generator.

3. Display

The display consists of three integrated counting decades, IC106 to IC108, for the units, tens and hundreds. The thousands are counted by flip-flop IC109a.
The decade counters count the number of clock pulses supplied via gate IC102b. The reset pulse is derived from the 1 Hz generator.

The output signals of IC106 to IC108 are converted to the digits 0...9 and displayed by indicators B103...B105. Decoding is effected in IC103...IC105, which incorporate the switching amplifiers for driving the indicator tubes.

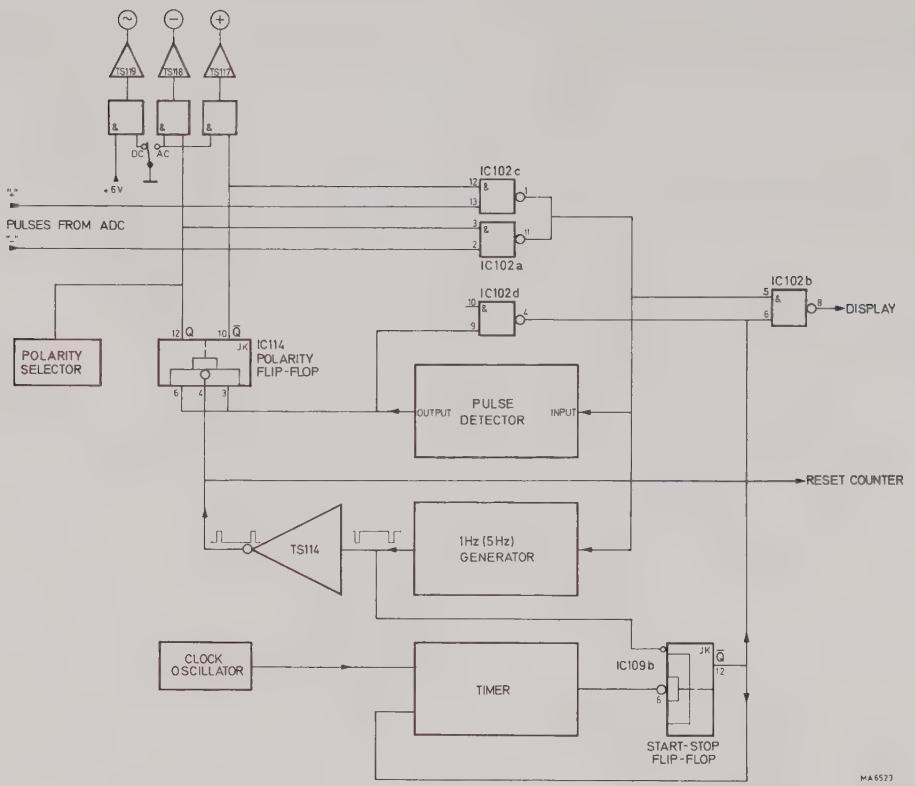


Fig. 26. Program circuit

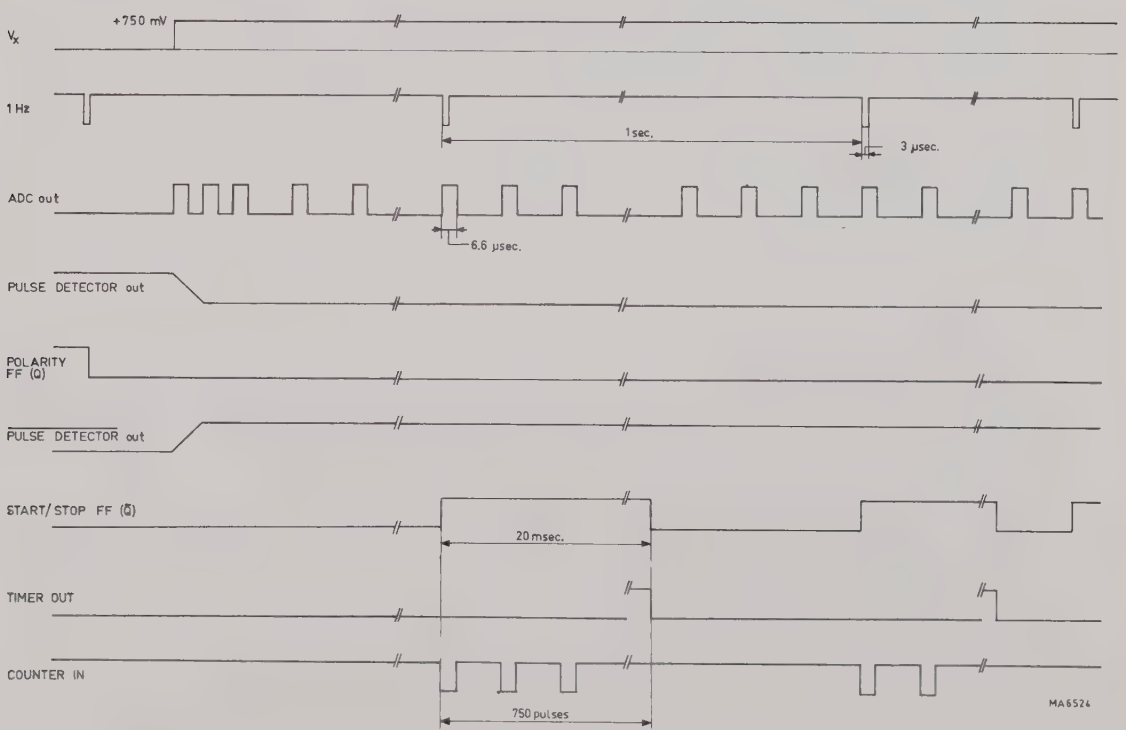


Fig. 27. Pulse diagram for positive input

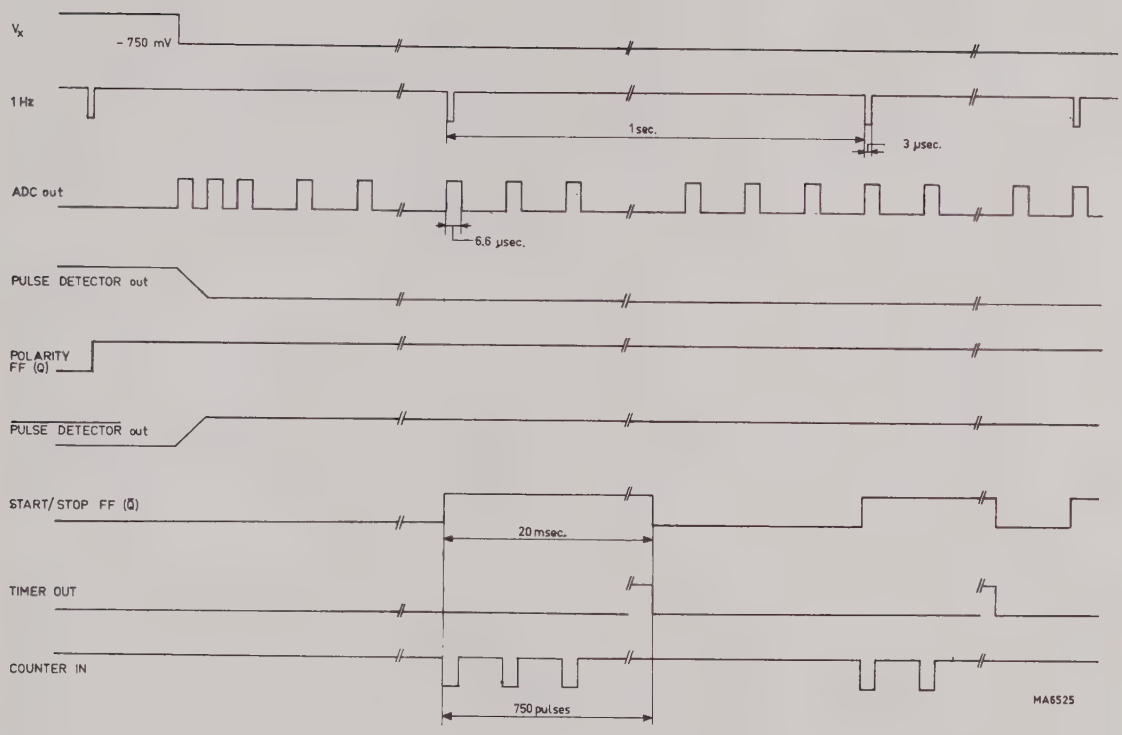


Fig. 28. Pulse diagram for negative input

VIII. Gaining access to the parts

A. REMOVING THE CABINET

The instrument chassis is constructed as a compact plug-in chassis and is accommodated in a 3-module standard cabinet. The chassis can be pulled out of the cabinet by means of the two locking devices at the front.
When these locking devices cannot be hinged out the two locking screws A (Fig. 32) should be loosened but not removed by means of the 2.5 mm Allen key, included in delivery.

B. PRINTED WIRING BOARDS (Fig. 35)

- Remove screw B
- Remove the four screws in the side panels which secure printed wiring board U2 (screws F, see Fig. 29)
- Unlock hook C of the print support
- Printed wiring board U2 can now be hinged down easily.
  All components on printed wiring boards U1 and U2 are now accessible. For U3 see VIII.D

C. RIGHT-HAND SIDE PANEL (Fig. 29)

- Remove 3 screws D
- Remove 2 screws E
- Remove 2 screws F
- The right-hand side panel can now be removed.

D. SWITCH SKIV

By removing the right-hand side panel (see VIII C), access can be gained to the switch wafers of SKIV and to printed wiring board U3.

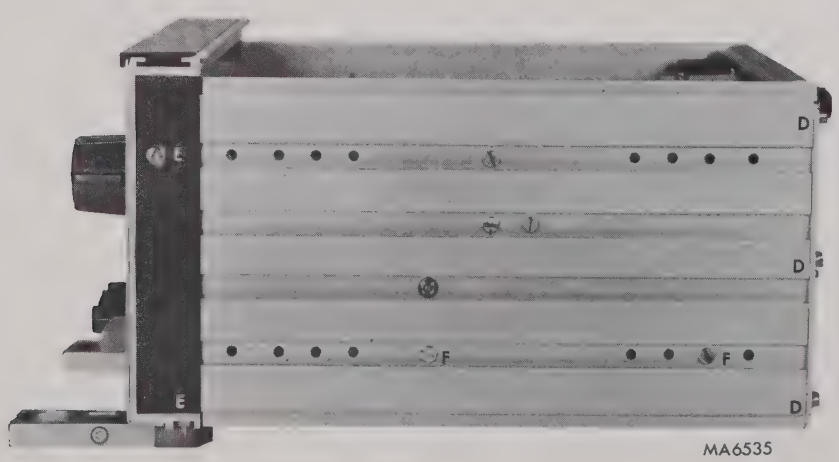


Fig. 29. Right-hand side panel

IX. Replacing parts

A. PRINTED WIRING BOARD U3 AND SWITCH WAFERS OF SKIV

- Remove the cabinet (VIII. A)
- Remove the right-hand side panel (VIII. C)
- Remove the plate securing the range selector to the side panel
- Unsolder the connection wires U3 from SKIII
- Remove the knob of the range selector and the nut below
- Switch SKIV can now be slide backwards after which the threaded ends through the switch wafers can be pushed forward

B. PUSH BUTTON SWITCH SKIII

- Remove the connection wires
- Loosen two screws G (Fig. 35)

C. TEXT PLATE

- Remove the input terminals BU1 to BU4
- Remove the switch POWER ON
- Remove the knob of the range selector and the nut below
- Remove two screws H (Fig. 35)
- Remove the ornamental strip. To do this it is necessary to depress the locking device which is located above indicator tube B103

D. FUSES

a. VL201

This fuse protects the shunt resistors R2050 to R2053 against overloads. If the fuse blows it can be replaced by sliding the chassis out of the cabinet. The fuse is located at the bottom of the instrument on printed wiring board U2 (Fig. 35)

b. VL202 and VL203

Fuses VL202 and VL203 protect the +15 V and -15 V supply. They are located at the bottom of the instrument on printed wiring board U2 (Fig. 35)

E. PRINTED WIRING BOARDS

1. U1

If printed wiring board U1 has been replaced the following adjustments should be carried out.

- + 5 V supply for the indicator drivers (see XII. A. 5)
- Clock pulse (see XII. B)
- Zero setting (see XII. D)
- 1 V, -1 V and 100 mV DC range (see XII. E. 1, 2, 3)

2. U2

If printed wiring board U2 has been replaced the following adjustments should be carried out.

- Stabilising current of B201 and B202 (see XII.A.2, and also IX.F)
- All supply voltages (see XII.A.3.4)
- 10 V DC range (see XII.E)
- Resistance ranges (see XII.F)
- AC-DC-converter (see XII.H)

3. U3

If printed wiring board U3 has been replaced only the AC attenuator should be checked (see XII.J).

F. NEON LAMPS B201 and B202

The +80 V and -80 V supply are very stable voltage sources, which are necessary for the ADC and resistance measurements.
The reference source is provided by neon lamps B201 and B202. To ensure the necessary accuracy, the lamps should be aged for 250 hours at a current of 3.2 mA. This is possible by the adjustment procedure according to XII.A.2.

The neon lamps appearing in the list of parts, as well as the lamps on printed wiring board U2 (which is supplied as a spare) are not aged.

X. Maintenance

In general, the digital multimeter does not require any maintenance, since it does not contain parts which are subject to wear.
Faultless operation and reliability can be maintained by avoiding exposure of the instrument to moisture, heat, corrosive fumes and excessive dust.

Trouble shooting

If the instrument appears to be out of order, it is advisable to check it systematically. The instructions shortly following may greatly facilitate the fault finding.

1. Data without tolerances represent the properties of an average instrument and serve only for guidance.
2. The r.m.s. values of the voltages of the mains transformer at no load are given in a table near the mains transformer in the circuit diagram (Fig. 40)
3. In the circuit diagram (Fig. 40) d.c. voltages are stated at the most important points. These voltages have been measured with electronic multimeter PM 2403.
4. Resistors R7 and R102 can become defective if an excessive voltage is applied to terminal V owing to excessively high power dissipation in these resistors.
5. First check if fuses VL201, VL202 and VL203 have blown.

Fig. 30 illustrates a systematic test diagram of the instrument. The individual tests are further described in the instructions below.

1. Checking the supply voltages

For checking of the supply voltages see chapters XIII.A.3 and XIII.A.4. Follow the sequence given in Fig. 30 (a, b, c, d and e). The current consumption for the various power supplies is shown in the table below.

Power supply	Current consumption
+80 V	approx. 3.1 mA
-80 V	approx. 3.1 mA
+15 V	approx. 90 mA
-15 V	approx. 60 mA
+ 6 V	approx. 350 mA

The load of the power supplies can be disconnected for checking purposes and replaced by a resistor the value of which is determined by voltage and current.

2. Checking the digital part

- Unsolder the wire from U1/43 (ADC input)
- Supply 1 V d.c. to the ADC input
- Set the range selector to 1 V
- The indication should be 1.000

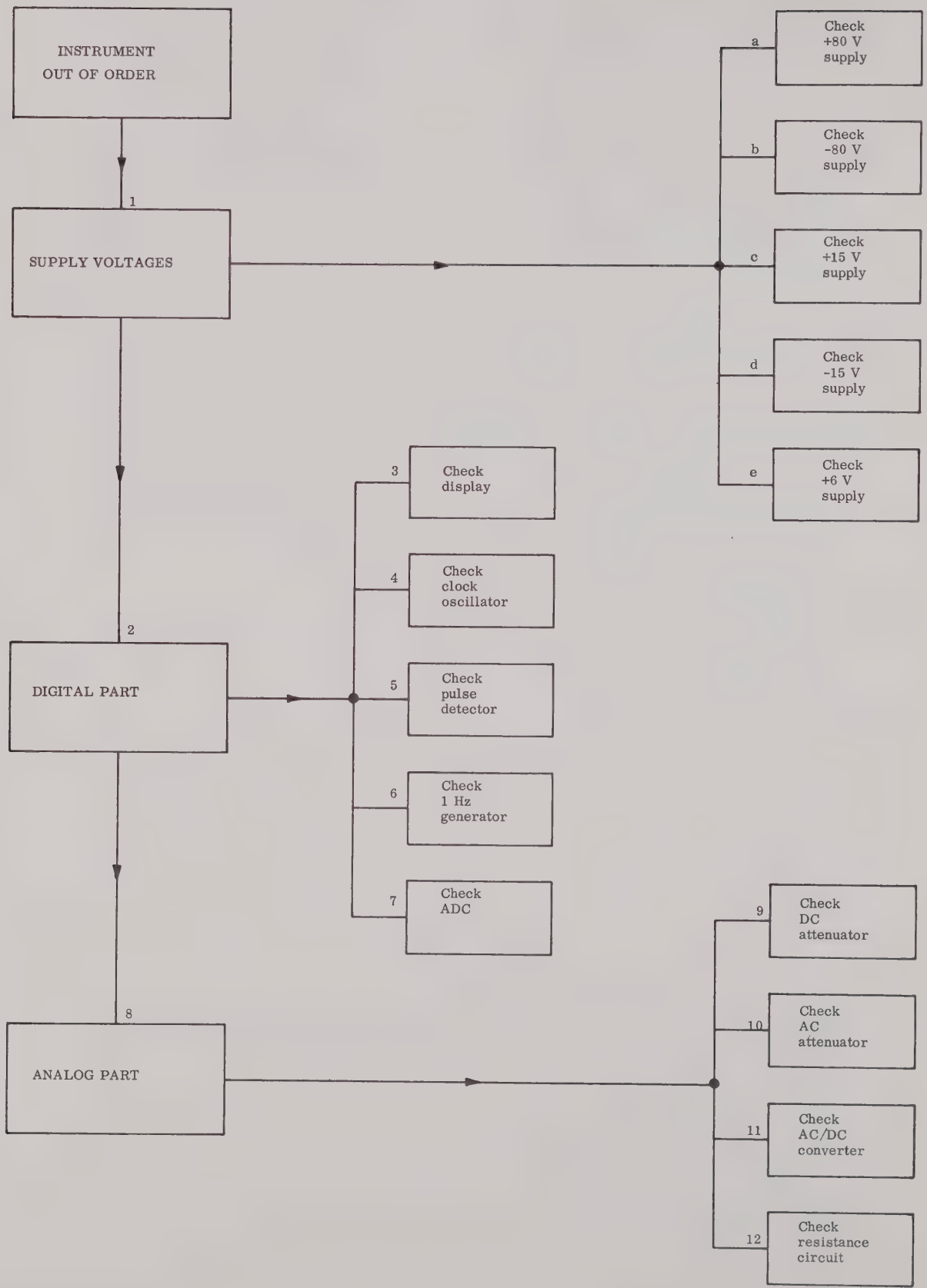


Fig. 30. Systematic test diagram

3. Checking the display

- Unsolder interconnection U1/75 - U1/77
- Set switch SKII to position HOLD
- Supply a square-wave voltage, amplitude greater than 3 V less than 6 V, frequency between 10 Hz and 10 kHz, to point U1/75
- After a certain time, depending on the frequency, the indicator tubes should count the number of pulses to a maximum of 1999.

4. Checking the clock oscillator

According to chapter XII.B.

5. Checking the pulse detector

According to chapter XII.C.

6. Checking the 1 Hz generator

- In position SLOW of switch SKII the indicators should blink once per second
- In position FAST the indicators should blink five time per second

7. Checking the ADC

- Supply +1 V to the ADC input (U1/43)
- Check that input K1 of IC101b (IC101b/9) is 1 (+3 V<1<+6 V)
- Check on an oscilloscope if output Q1 of IC101b (IC101b/12) supplies ADC pulses
- Supply -1 V to the ADC input (U1/43)
- Check that input K2 of IC101a (IC101a/5) is 1 (+3 V<1<+6 V)
- Output Q3 and Q4 of IC101a (IC101a/1 and IC101a/2) supply ADC pulses

8. Checking the analog part

Determine which measuring mode is defective by measuring a known voltage (a.c. and d.c.), current (a.c. and d.c.) or resistance.

9. Checking the d.c. attenuator

- Depress button DC (SKIII/1)
- Supply 1 V d.c. to terminals V (BU4) and 0 (BU2)
- Measure the input voltage of the ADC (U1/43) in all voltage ranges

Input voltage	Range	Voltage at the ADC input
1 V	.1 V	1 V
1 V	1 V	1 V
1 V	10 V	100 mV
1 V	100 V	10 mV
1 V	1000 V	1 mV

The voltages can be measured with a d.c. μV-voltmeter (e.g. PM 2435, PM2436)

10. Checking the a.c. attenuator

- Depress button AC (SKIII/2)
- Supply 1 V a.c., 300 Hz, to terminals V (BU4) and 0 (BU2)
- Measure the input voltage of the a.c. to d.c. converter (U2/50) in all voltage ranges

Input voltage	Range	Voltage at the a.c. to d.c. converter input
1 V	.1 V	1 V
1 V	1 V	1 V
1 V	10 V	10 mV
1 V	100 V	10 mV
1 V	1000 V	1 mV

- The voltages can be measured with an a.c. millivoltmeter (e.g. PM 2454)

11. Checking the a.c. to d.c. converter

- Supply 1 V a.c., 300 Hz, to the input of the a.c. to d.c. converter (U2/50)
- The output voltage of the a.c. to d.c. converter should be 1 V d.c. The voltage can be measured with a d.c. voltmeter (e.g. PM 2435)

12. Checking the resistance circuit

- Connect a d.c. current meter to input terminals "0" (BU2) and I.R. (BU3)
- Check the current in the resistance ranges

Range	Current
100 Ω	1 mA
1 kΩ	1 mA
10 kΩ	100 μA
100 kΩ	10 μA
1 MΩ	1 μA
10 MΩ	0.1 μA

- The currents can be measured with a d.c. current meter (e.g. PM 2436)

Shipment of the instrument

In case of breakdowns one can always apply to the world-wide PHILIPS Service Organisation for assistance.

Whenever the instrument is sent to a PHILIPS Service Centre the following should be observed:

- Tie on a label bearing your full name and address
- Specify the fault(s) found
- Carefully pack the instrument in a sealed plastic bag and then in its original packing, or if this is not available, a wooden case
- Send the instrument to the address provided by your local PHILIPS representative

XI. Survey of adjustments

The checking and adjusting procedure is explained in chapter XII.

Control element	Fig.	Checking or adjusting point	Auxiliary equipment	Point of chapter XII
--	--	Current consumption	Multimeter (e.g. PM 2403)	A.1
R2104	35	Stabilising current of B201 and B202	Multimeter (e.g. PM 2403)	A.2
R2093	35			
R2110	35	-80 V supply	Digital voltmeter (e.g. PM 2421) Oscilloscope (e.g. PM 3221)	A.3
R2097	35	+80 V supply		
R2116	35	+15 V supply		A.4
R2122	35	-15 V supply		
R2130	35	+ 6 V supply		
R2101	35	+1.100 V supply		
R2111	35	-1.100 V supply		
R177	36	+ 5 V supply		A.5
R168	36	Clock oscillator	Counter (e.g. PM 6630) Oscilloscope (e.g. PM 3221)	B
C109	36			
C110	36			
--		Pulse detector	Pulse generator (e.g. PM 5770)	C
R1	33	Zero setting	DC supply 1 mV ± 3 %	D
R112	36			
R115	36			
R107	36			
R109	36			
R2	34	1 V DC range	DC supply 100 mV... 1000 V ± 0.02 %	E
R143	36	100 mV DC range		
R3	34	- 1 V DC range		
R2057	35	10 V DC range		
--	--	100 V DC range		
--	--	1000 V DC range		
--		100 Ω range	Resistor 11 Ω ± 0.1 %	F
--		1 kΩ range	Resistor 110 Ω ± 0.1 %	
--		10 kΩ range	Resistor 1100 Ω ± 0.1 %	
R2076	35	100 kΩ range	Resistor 11 kΩ ± 0.1 %	
R2068	35	1 MΩ range	Resistor 110 kΩ ± 0.1 %	
R2069	35		Resistor 1 MΩ ± 0.1 %	
R6	-		Resistor 1.4 MΩ ± 0.1 %	
R2063	35	10 MΩ range	Resistor 10 MΩ ± 0.1 %	
R2064	35		Two decade boxes 10 MΩ max.	
R2060	35			

Control element	Fig.	Checking or adjusting point	Auxiliary equipment	Point of chapter XII
--		DC current ranges	DC current source 0.11 mA...1.1 A ± 0.05 %	G
R2003	35	AC-DC-converter	Multimeter (e.g. PM 2403) AC supply 110 mV...1.1 V ± 0.05 % 1 kHz Oscilloscope (e.g. PM 3221)	H
R2043	35			
R2021	35			
R2013	35			
R2014	35			
R2022	35			
C303	36	AC attenuator	AC supply 11 V...300 V ± 0.05 % 330 Hz...30 kHz	J
C307	36			
--		AC current ranges	AC current source 0.11 mA ± 0.05 %,330 Hz	K

XII. Checking and adjusting

When numerical values are shown with tolerances in this chapter, the values represent factory data and apply only when the instrument has been re-adjusted.
Such data may differ from these showns under Technical Data in chapter II.
Values without tolerances stated represent the propertes of an average instrument and serve merely for reference.

A. SUPPLY

1. Current consumption

For 220 V mains: 125 mA max.
For 110 V mains: 250 mA max.

2. Adjusting the hold current of B201 and B203

- Adjust the voltage across R2103 to 3.1 V ± 5 % with R2104.
- Adjust the voltage across R2094 to 2.2 V ± 5 % with R2093.

3. -80 V and +80 V supply

- Adjust the output voltage of the -80 V supply to -79.7 V + or -0.15 V with R2110.
  Measuring points: U2/23 (-) and U2/20 (0).
- Check the ripple voltage of the -80 V supply. This should be < 80 mV_{p-p}.
- Adjust the output voltage of the +80 V supply to +79.7 V + or - 0.15 V with R2097.
  Measuring points U2/18 (+) and U2/20 (0).
- Check the ripple voltage of the +80 V supply. This should be <80 mV_{p-p}.

4. +15 V, -15 V, +6 V, +1.100 V and -1.100 V supply

Supply circuit	Adjust to		Adjust with	Measuring point	Ripple voltage
+15 V	+15 V	± 80 mV	R2116	U2/13 and U2/15	< 15 mV_{p-p}
-15 V	-15 V	± 80 mV	R2122	U2/16 and U2/15	< 15 mV_{p-p}
+6 V	6 V	± 30 mV	R2130	U2/11 and U2/12	< 15 mV_{p-p}
+1.100 V	+1.100 V	± 300 µV	R2101	U2/19 and U2/20	--
-1.100 V	-1.100 V	± 300 µV	R2111	U2/21 and U2/20	--

5. +5 V for drivers

- Adjust the +5 V supply for the indicator drivers to +5 V ± 5 % with R177.
  Measuring points: junction R177/R178/ point 5 of IC 103 and zero.

B. CLOCK OSCILLATOR

- Connect an oscilloscope and a counter to U1/7.
- Adjust the repetition frequency to 150 kHz ± 1 % with R168, C109 and C110.
- Check the clock-pulse form (Fig. 31).

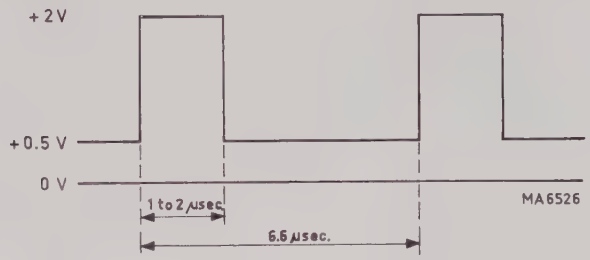


Fig. 31. Clock pulse

C. PULSE DETECTOR

- Remove jumper U1/50 - U1/51.
- Unsolder the wire from point U1/18 supply pulses to this point (input pulse detector), pulse width 6.6 µsec., amplitude +5 V.
- At a repetition time of 100 msec. the + or - indication should be held.
- At a repetition time of 400 msec. the + or - indication should be alternate.

D. ZERO SETTING

- Supply alternately + 1 mV + or -30 µV and -1 mV + or -30 µV to terminals BU2 and BU4.
- Set range selector SKIV to position .1 V.
- Depress button DC (SKIII/1)
- Set switch SKII to position FAST.
- Adjust the indication to +.0009 and -.0009 with R112 (coarse), R115 (fine) and zero potentiometer R1.
- Set R1 to mid-position.
- Adjust the indication to +.0009 and -.0009 with R107 and R109.
- Set range selector SKIV to position 1 V.
- The indication should be +0.001 and -0.001.

E. CHECKING AND ADJUSTING THE DC RANGES

1. 1 V range

- Supply +1.1 V ±0.02 %.
- Adjust the indication to +1.100 with R2.

2. 100 mV range

- Supply +110 mV ±0.02 %
- Adjust the indication to +110.0 with R143.

Repeat E.1. and E.2.

3. -1 V range

- Supply -1.1 V ± 0.02 %.
- Adjust the indication to -1.100 with R3.

4. 10 V range

- Supply +11 V ±0.02 %.
- Adjust the indication to +11.00 with R2057.

5. 100 V range

- Supply +110 V ± 0.02 %
- The indication should be +110.0 ± 2 digits.

6. 1000 V range

- Supply +1000 V ± 0.02 %.
- The indication should be +1000 ± 2 digits.

F. CHECKING AND ADJUSTING THE RESISTANCE RANGES

- Release buttons DC and AC.
- Check the resistance ranges according to the following table.

Range	Connect to terminals BU2 (0) and BU3 (I.R.)		Indication	Adjust with
100 Ω	11 Ω	± 0.1 %	011.0 ± 5 digits	-----
100 Ω	110 Ω	± 0.1 %	110.0 ± 5 digits	-----
1 kΩ	110 Ω	± 0.1 %	0.110 ± 5 digits	-----
1 kΩ	1100 Ω	± 0.1 %	1.100 ± 5 digits	-----
10 kΩ	1100 Ω	± 0.1 %	01.10 ± 5 digits	-----
10 kΩ	11 kΩ	± 0.1 %	11.00 ± 5 digits	-----
100 kΩ	110 kΩ	± 0.1 %	110.0 ± 5 digits	R2076
100 kΩ	11 kΩ	± 0.1 %	011.0 ± 5 digits	-----

1 MΩ range

- Connect a resistor, 1 MΩ ± 0.1 %, to terminals BU2 (0) and BU3 (I.R.).
- Replace series connection R2068 + R2069 by a resistance decade box (max, 10 MΩ).
- Adjust the indication to 1.000 ± 5 digits with the box.
- Connect a resistor, 1.4 MΩ ± 0.1 %, to terminals BU2 and BU3.
- Replace resistor R6 by a second decade box (10 MΩ) and adjust this box in such a way that the indication deviates as little as possible from 1.400.
- Connect the 1 MΩ resistor again to terminals BU2 and BU3.
- The indication should be 1.000 ± 5 digits. If necessary, readjust the decade box mounted for R2068 + R2069 + R2072.
- Connect the 1.4 MΩ resistor again to terminals BU2 and BU3.
- The deviation from 1400 should be as little as possible (max. + or - 14 digits). If necessary, readjust the decade box mounted for R6.
- Connect a resistor, 110 kΩ ± 0.1 %, to terminals BU2 and BU3.
- The indication should be 0.110 ± 10 digits.
- Mount the resistance values established with the resistance boxes.

10 MΩ range

- Connect a resistor, 10 MΩ ± 0.1 %, to terminals BU2 and BU3.
- Short circuit R2060 and adjust the indication to 10.00 ± 5 digits with R2063 and R2064. If necessary, R2060 can be used for correction.
- Connect a resistor, 1 MΩ ± 0.1 %, to terminals BU2 and BU3.
- The indication should be 01.00 ± 5 digits.

G. CHECKING THE DC CURRENT RANGES

- Depress button DC.
- Check the current ranges according to the following table.

Range	Supply to terminals BU2 (0) and BU3 (I.R.)	Indication
.1 mA	0.11 mA ± 0.05 %	.1100 ± 3 digits
1 mA	1.1 mA ± 0.05 %	1.100 ± 3 digits
10 mA	11 mA ± 0.05 %	11.00 ± 3 digits
100 mA	110 mA ± 0.05 %	110.0 ± 3 digits
1000 mA	1.1 A ± 0.05 %	1100 ± 3 digits

H. ADJUSTING THE AC-DC CONVERTER

- Interconnect input terminals BU2 (0) and BU4 (V).
- Depress button AC (SKIII/2).
- Set range selector SKIV to 1 V.
- Connect a d.c. voltmeter between zero and the negative side of C205.
- Adjust the voltmeter indication to 0 V ± 20 mV with R2003.
- Connect a d.c. voltmeter between zero and the negative side of C210.
- Adjust the voltmeter indication to 0 V ± 10 mV with R2043.
- Remove the interconnection BU2 - BU4.
- Supply 1.1 V ± 0.05 %, 1 kHz, to input terminals BU2 (0) and BU4 (V).
- Set potentiometer R2022 to its mid-position.
- The indication should be 1.000 ± 8 digits. If necessary, adjust with R2021. Note the indicated value neglecting the point (e.g. 1102).
- Check the wave form at the negative side of C210 with an oscilloscope. The form should be nearly sinusoidal.
- Supply 110 mV ± 0.05 %, 1 kHz, to the input.
- Set range selector SKIV to .1 V.
- Adjust the indication with R2014 to the value (e.g. 1102) noted. If necessary, use also R2013.
- Set range selector SKIV to 1 V.
- Adjust the indication with R2043 to the value noted (e.g. 1102).
- Set range selector SKIV to .1 V.
- Adjust the indication with R2014 (R2013) to the value noted.
- Supply 1.1 V ± 0.05 %, 1 kHz to the input.
- Set the range selector SKIV to 1 V.
- Adjust the indicaton to 1.100 ± 1 digit with R2022.

J. ADJUSTING THE AC ATTENUATOR

Range	Supply to terminals BU2 (0) and BU4 (V)	Indication	Adjust with
10 V	11 V ± 0.05 %, 330 Hz	11.00 ± 2 digits	----
10 V	11 V ± 0.05 %, 30 kHz	11.00 ± 1 digit	C307
100 V	110 V ± 0.05 %, 330 Hz	110.0 ± 2 digits	----
1000 V	300 V ± 0.05 %, 330 Hz	0300 ± 2 digits	----
1000 V	300 V ± 0.05 %, 30 kHz	0300 ± 2 digits	C303

K. CHECKING THE AC CURRENT RANGES

- Set range selector SKIV to position .1 mA.
- Depress button AC (SKIII/2).
- Supply 0.11 mA ± 0.05 %, 330 Hz.
- The indication should be .1100 ± 3 digits.

XIII. Parts list

A. MECHANICAL

Pos.	Fig.	Qty.	Ordering number	Description
1	32	1	5322 460 60017	Ornamental frame (6 modules)
2	32	1	5322 413 40112	Knob
3	32	1	5322 413 70037	Cap for knob
4	32	2	5322 417 54001	Locking device
5	32	1	5322 276 20145	Push-button switch SKIII
6	32+33	6	5322 290 40011	Terminal BU1...BU6
7	32	1	5322 290 30001	Interconnection strip
8	32	1	5322 277 20009	Slide switch SKII
9	32	1	5322 277 20021	Power-on switch SKI
10	32	1	5322 455 90402	Text plate, front
11	32	1	5322 450 60068	Window
12	33	1	5322 455 90403	Text plate, rear
13	33	1	5322 255 40091	Cap for power transistor
14	33	1	5322 255 40072	Mica insulating washer
15	33	1	5322 256 40026	Fuse holder VL2
16	33	1	5322 265 30066	Mains connection BU7
17	33	1	5322 277 20014	Slide switch SKV
18	33	1	5322 256 30056	Fuse holder VL1
19	33	1	5322 535 80505	Distance piece
20	33	4	5322 256 90115	Printholder
21	33	1	5322 693 40001	Printholder
22	34	5	5322 255 70145	Indicator holder
23	34	3	5322 255 40098	IC socket
24	34	2	5322 466 90738	Printholder
25	34	1	5322 273 80153	Switch SKIV
26	35	2	5322 255 40044	Heat sink for TS222 and TS227
27	-	1	5322 395 50085	Allen key 2.5 mm
28	-	1	5322 290 40077	Measuring terminal
29	-	1	5322 321 10071	Mains cable

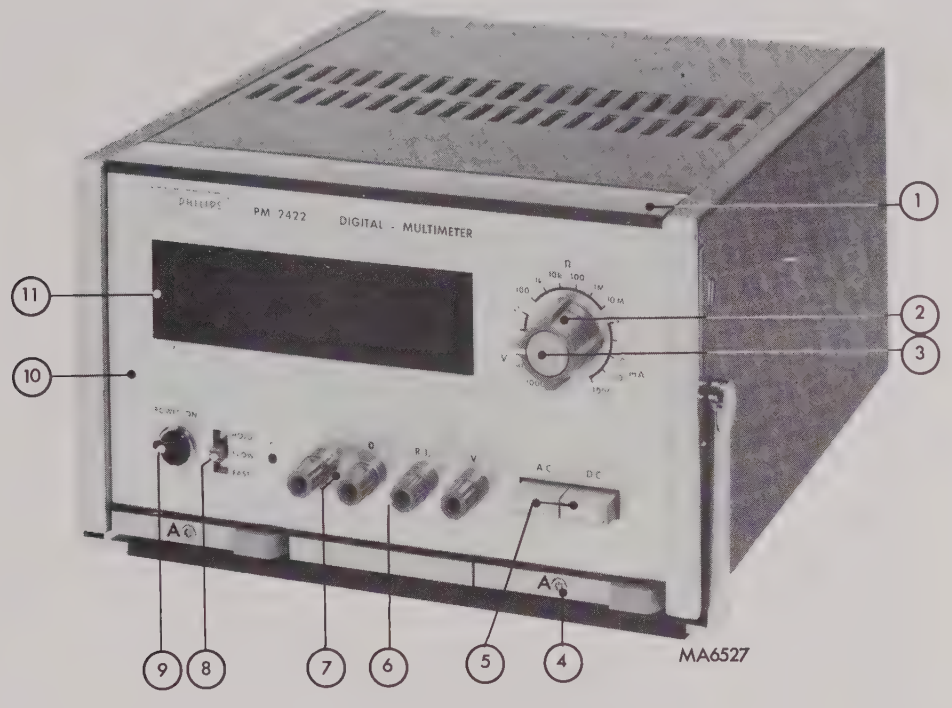


Fig. 32. Front view with item numbers

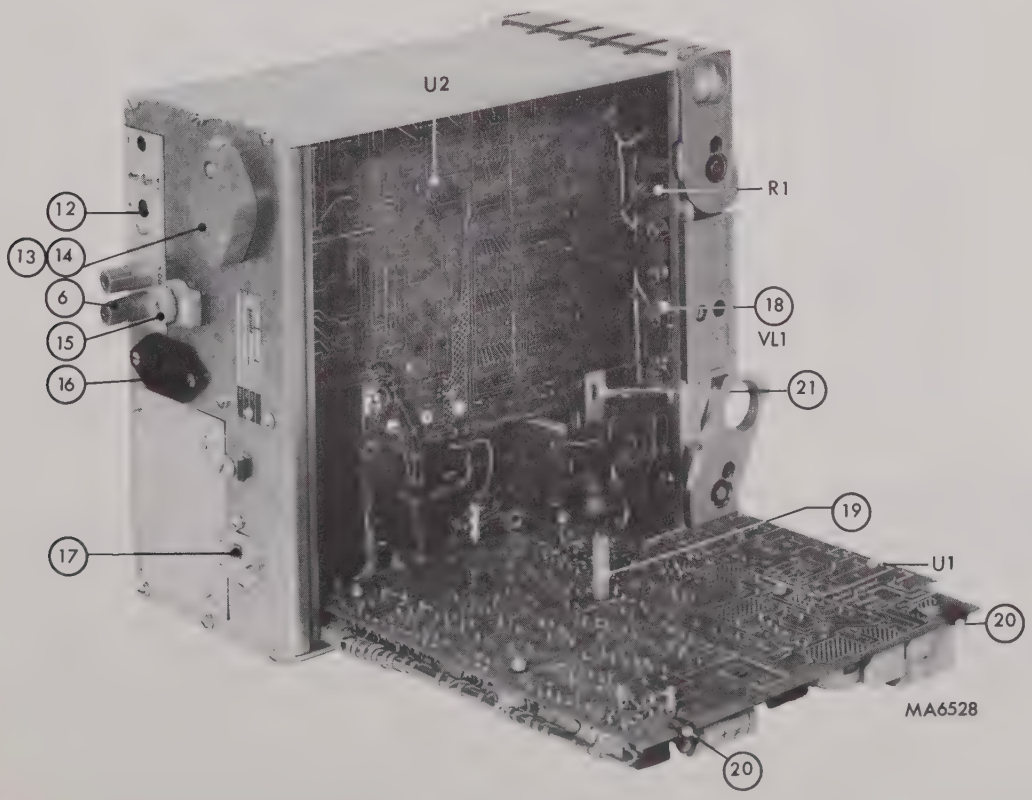


Fig. 33. Bottom view (printed wiring board hinged down)

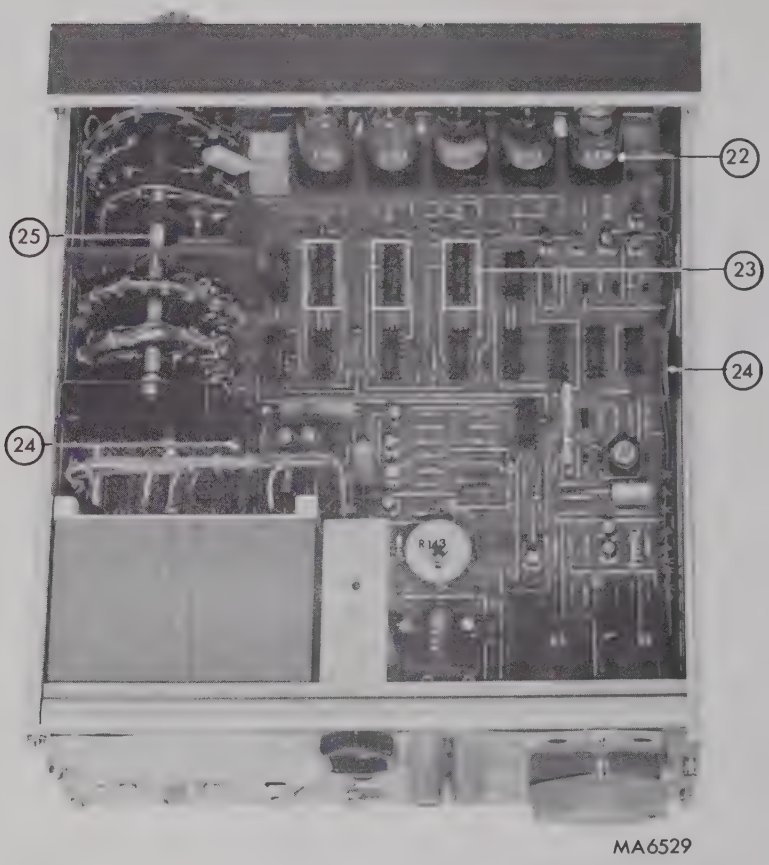


Fig. 34. Top view

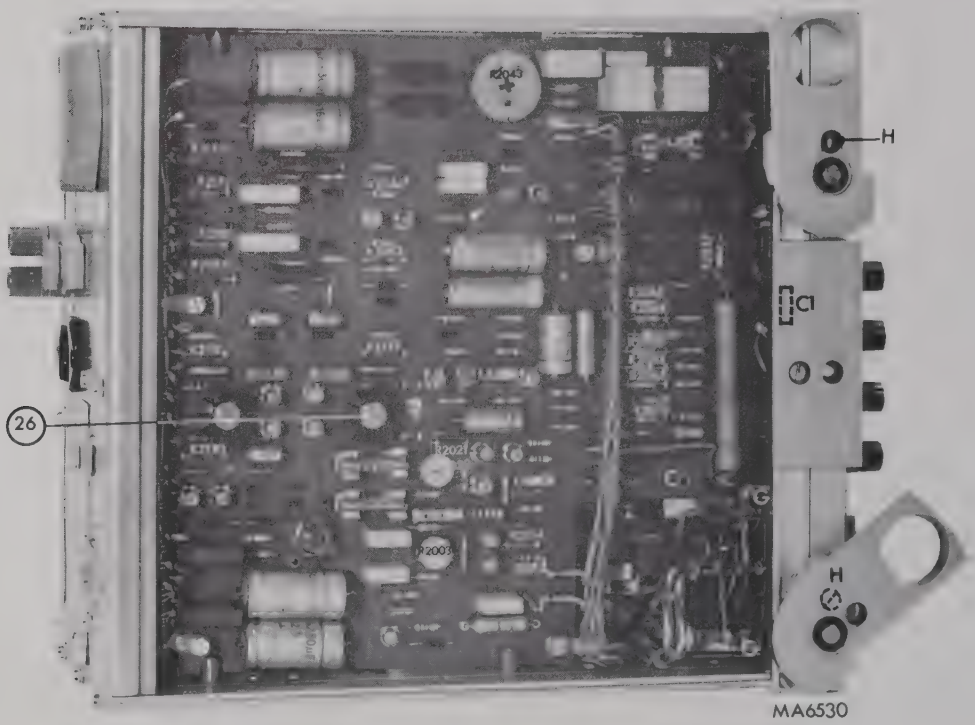


Fig. 35. Bottom view

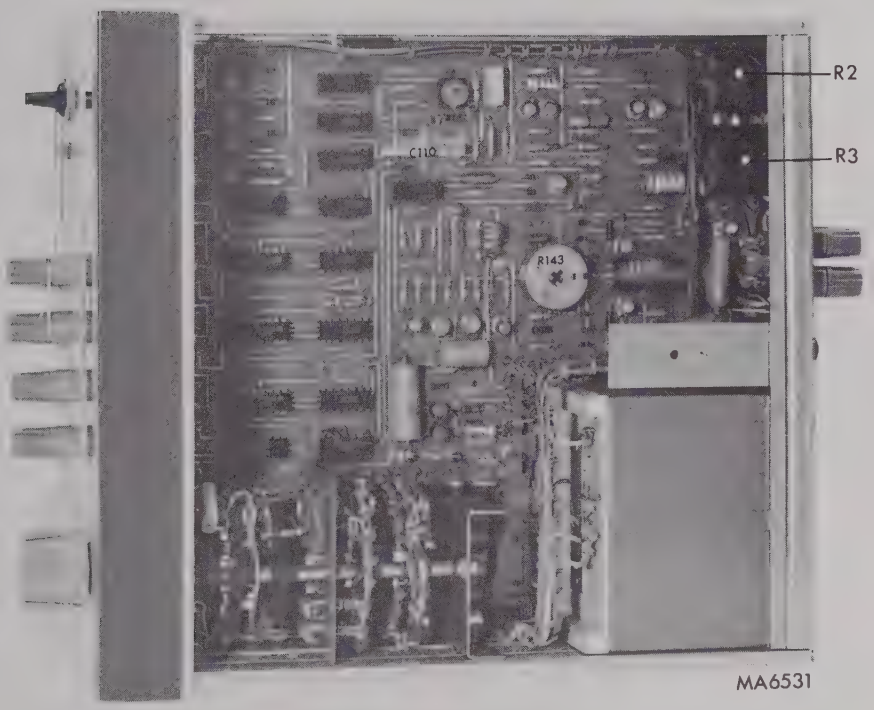


Fig. 36. Top view

B. ELECTRICAL — ELEKTRISCH — ELEKTRISCH — ELECTRIQUE — ELECTRICOS

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Diese Ersatzteilliste enthält keine Universal- und Standard-Teile. Diese sind im jeweiligen Prinzipschaltbild mit Kennzeichnungen versehen. Die Spezifikation kann aus nachstehender Übersicht abgeleitet werden.

In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

La présente liste ne contient pas des pièces universelles et standard. Celles-ci ont été repérées dans le schéma de principe. Leurs specifications sont indiquées ci-dessous.

Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,125 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,25 W ≦ 1 MΩ, 5%
> 1 MΩ, 10%

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,5 W ≦ 5 MΩ, 1%
> 5 ≦ 10 MΩ, 2%
> 10 MΩ, 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,5 W ≦ 1,5MΩ, 5%
> 1,5MΩ, 10%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
10 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
1 W ≦ 2,2 MΩ, 5%
> 2,2 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
2 W 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
0,4 – 1,8 W 0,5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
5,5 W ≦ 200 Ω, 10%
> 200 Ω, 5%

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
500 V

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
700 V

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
500 V

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
30 V

Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
500 V

Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
400 V

Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
250 V

Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
1000 V

Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado

Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

Resistors

No.	Ordering number	Value	%	Series	Description
R1	5322 103 20033	1 kΩ	10		Potentiometer
R2	4822 103 20091	4.7 kΩ	5	1 Watt	Potentiometer
R3	4822 103 20091	4.7 kΩ	5	1 Watt	Potentiometer
R103	5322 110 60194	1.8 MΩ	5	CR25	Carbon
R104	5322 110 60194	1.8 MΩ	5	CR25	Carbon
R105	5322 116 50762	20.5 kΩ	1	MR25	Metal film
R106	5322 116 50757	51.1 Ω	1	MR25	Metal film
R108	5322 116 50757	51.1 Ω	1	MR25	Metal film
R110	5322 116 50396	20.5 kΩ	1	MR25	Metal film
R111	5322 116 50748	10 kΩ	1	MR25	Metal film
R113	5322 116 50672	51.1 kΩ	1	MR25	Metal film
R114	5322 116 50762	5.11 kΩ	1	MR25	Metal film
R125	5322 116 40011	60 Ω			Thermistor
R129	5322 116 50524	3.01 kΩ	1	MR25	Metal film
R130	5322 116 51008	34.4 kΩ	0.25	MR31C	Metal film
R131	5322 111 30059	3.9 MΩ	5	CR25	Carbon
R135	5322 116 50524	3.01 kΩ	1	MR25	Metal film
R136	5322 116 51009	37.4 kΩ	0.25	MR31C	Metal film
R141	5322 116 50964	1.35 kΩ	0.25	MR31C	Metal film
R142	5322 116 50259	1.69 kΩ	1	MR25	Metal film
R143	4822 101 10126	1 kΩ	10	2 Watt	Potentiometer
R146	5322 116 50585	162 Ω	0.25	MR31C	Metal film
R179	5322 111 30342	10 MΩ	10	CR25	Carbon
R182	5322 111 30342	10 MΩ	10	CR25	Carbon
R185	5322 111 30342	10 MΩ	10	CR25	Carbon
R188	5322 111 30342	10 MΩ	10	CR25	Carbon
R191	5322 111 30342	10 MΩ	10	CR25	Carbon
R2003	5322 100 10146	100 Ω	20	0.1 Watt	Potentiometer
R2015	5322 116 50765	909 Ω	1	MR25	Metal film
R2018	5322 116 50361	17.8 kΩ	1	MR25	Metal film
R2019	5322 116 50525	14.7 kΩ	1	MR25	Metal film
R2020	5322 116 50294	2.32 kΩ	1	MR25	Metal film
R2022	5322 100 10146	100 Ω	20	0.1 Watt	Potentiometer
R2023	5322 116 50579	3.16 kΩ	1	MR25	Metal film
R2025	5322 116 50675	2.26 Ω	1	MR25	Metal film
R2026	5322 116 50675	2.26 kΩ	1	MR25	Metal film
R2040	5322 116 50608	6.19 kΩ	1	MR25	Metal film
R2042	5322 116 50583	5.9 kΩ	1	MR25	Metal film
R2043	5322 103 10143	68 Ω	10	2 Watt	Potentiometer
R2044	5322 116 50583	5.9 kΩ	1	MR25	Metal film
R2050	5322 115 80099	0.1 Ω + 0.9 Ω	1		Shunt
R2051	5322 113 10177	9 Ω	0.25	0.4 Watt	Wire wound
R2052	5322 116 50944	90 Ω	0.25	MR31C	Metal film
R2053	5322 116 50942	900 Ω	0.25	MR31C	Metal film
R2054	5322 116 51019	900 kΩ	0.1	MR58C	Metal film

No.	Ordering number	Value		%	Series	Description
R2055	5322 116 51013	90	kΩ	0.25	MR31C	Metal film
R2056	5322 116 50748	10	kΩ	0.25	MR31C	Metal film
R2059	5322 116 51006	8.66	MΩ	1	2 Watt	Metal film
R2061	5322 111 30342	10	MΩ	10	CR25	Carbon
R2062	5322 111 30342	10	MΩ	10	CR25	Carbon
R2066	5322 111 30342	10	MΩ	10	CR25	Carbon
R2067	5322 111 30342	10	MΩ	10	CR25	Carbon
R2071	4822 110 60194	1.8	MΩ	5	CR25	Carbon
R2073	5322 116 50765	909	Ω	1	MR25	Metal film
R2074	5322 116 51018	787	kΩ	0.25	MR58C	Metal film
R2075	5322 116 51012	78.7	kΩ	0.25	MR31C	Metal film
R2095	5322 116 50573	1	kΩ	1	MR25	Metal film
R2099	5322 116 51027	301	kΩ	0.25	MR39C	Metal film
R2100	5322 116 51011	4.17	kΩ	0.25	MR31C	Metal film
R2108	5322 116 50573	1	kΩ	1	MR25	Metal film
R2112	5322 116 51011	4.17	kΩ	0.25	MR31C	Metal film
R2113	5322 116 51027	301	kΩ	0.25	MR39C	Metal film
R2115	5322 116 50537	9.09	kΩ	1	MR25	Metal film
R2118	5322 116 50151	7.5	kΩ	1	MR25	Metal film
R2120	5322 116 50151	7.5	kΩ	1	MR25	Metal film
R2121	5322 116 50537	9.09	kΩ	1	MR25	Metal film
R2125	5322 113 60104	1.2	Ω	10	1 Watt	Glass-sealed wire
R2127	5322 116 50853	5.62	kΩ	1	MR25	Metal film
R2128	5322 116 50635	1.47	kΩ	1	MR25	Metal film
R2129	5322 116 50657	6.81	kΩ	1	MR25	Metal film
R301	5322 116 51022	999	kΩ	0.1	MR58C	Metal film
R302	5322 116 50747	1	kΩ	0.1	MR31C	Metal film
R303	5322 116 51021	990	kΩ	0.1	MR58C	Metal film
R304	5322 116 50748	10	kΩ	0.1	MR31C	Metal film
R305	5322 116 50022	1	MΩ	1	MR58C	Metal film
R306	5322 111 30342	10	MΩ	10	CR25	Carbon

Capacitors

No.	Ordering number	Value		%	V	Description
C1	4822 120 60112	1.5	nF	5	500	Mica
C2	5322 121 40192	10	nF	10	630	Polyester
C3	5322 124 70217	2200	μF		25	Electrolytic
C101	4822 124 20349	6.4	μF		6.4	Electrolytic
C102	5322 121 50296	51	nF	2	63	Polystyrene
C103	5322 121 50403	15	nF	2	63	Polystyrene
C104	4822 124 20355	12.5	μF		25	Electrolytic
C105	4822 124 20467	16	μF		10	Electrolytic
C107	4822 124 20363	20	μF		6.4	Electrolytic
C111	5822 121 50395	1.8	nF	5	63	Polystyrene

No.	Ordering number	Value		%	V	Description
C112	5322 121 40323	100	nF	10	100	Polycarbonate
C113	5322 121 40323	100	nF	20	100	Polycarbonate
C114	5322 121 40323	100	nF	20	100	Polycarbonate
C115	5322 121 40323	100	nF	20	100	Polycarbonate
C116	5322 121 40323	100	nF	20	100	Polycarbonate
C4	5322 120 14001	1.5 nF		20	400	Ceramic
C5	5322 120 14001	1.5 nF		20	400	Ceramic
C117	5322 124 10017	15	µF		20	Electrolytic, tantal
C118	4822 124 20147	32	µF		4	Electrolytic
C201	5322 121 40192	10	nF	20	630	Polyester
C205	4822 124 20379	80	µF		16	Electrolytic
C206	4822 124 20399	200	µF		10	Electrolytic
C207	4822 124 20402	320	µF		6.4	Electrolytic
C208	5322 124 10081	330	µF		6	Electrolytic, tantal
C210	4822 124 20394	125	µF		6.4	Electrolytic
C211	5322 124 10074	150	µF		6	Electrolytic, tantal
C212	5322 121 40252	6.8	µF	10	100	Polycarbonate
C213	5322 121 40197	1	µF	10	100	Polycarbonate
C214	5322 121 40231	0.15	µF	10	100	Polycarbonate
C215	5322 121 40323	100	nF	20	100	Polycarbonate
C216	5322 121 40323	100	nF	20	100	Polycarbonate
C217	5322 121 40323	100	nF	20	100	Polycarbonate
C218	5322 121 40323	100	nF	20	100	Polycarbonate
C219	5322 121 50424	1	nF	5	63	Polystyrene
C220	4822 124 20433	16	µF		300	Electrolytic
C221	5322 121 40257	330	nF	20	100	Polycarbonate
C222	4822 124 20433	16	µF		300	Electrolytic
C223	5322 121 40257	330	nF	20	100	Polycarbonate
C224	4822 124 20399	250	µF		40	Electrolytic
C226	4822 124 20466	4	µF		10	Electrolytic
C227	4822 124 20362	20	µF		16	Electrolytic
C228	4822 124 20399	250	µF		40	Electrolytic
C230	4822 124 20466	4	µF		10	Electrolytic
C231	4822 124 20362	20	µF		16	Electrolytic
C232	4822 124 20362	20	µF		16	Electrolytic
C301	4822 122 10044	62	pF	1	500	Ceramic
C302	4822 122 10044	62	pF	1	500	Ceramic
C303	5322 125 60027	6	pF			Trimmer
C304	5322 121 50347	27	nF	5	63	Polystyrene
C305	4822 122 10044	62	pF	1	500	Ceramic
C306	4822 122 10044	62	pF	1	500	Ceramic
C307	5322 125 60027	6	pF			Trimmer
C308	5322 121 50435	2.7	nF	1	125	Polystyrene
C309	5322 121 40226	220	nF	20	630	Polycarbonate
C310	5322 121 40257	330	nF	20	100	Polycarbonate

Miscellaneous

Item	Ordering number	Description
T1	5322 146 30275	Transformer
VL1	5322 252 60019	Spark gap
VL2	4822 253 30016	Mains fuse 400 mA (for 220 V mains)
	4822 253 30019	Mains fuse 800 mA (for 110 V mains)
U1	5322 216 70136	Printed wiring board, complete
U2	5322 216 70137	Printed wiring board, complete
U3	5322 216 70138	Printed wiring board, complete
L1	5322 158 10052	Coil
L2		
RE101	4822 280 20028	Relay
B1001	4822 134 20102	Neon lamp GL6
B1002	4822 131 90031	Indicator ZM1000
B1003		
B1004		
B1005		
B1006	4822 131 90038	Indicator ZM1001
B201	4822 131 40006	Stabiliser ZZ1000
B202		
VL201	4822 253 20017	Fuse 2A
VL202	4822 253 20006	Fuse 100 mA
VL203		

SEMICONDUCTORS

Transistors

Type	Ordering number	Qty	Item
BDY20	5322 130 40449	1	TS1
ON285	5322 130 40702	1	TS101 + TS102 (transistorpair)
BCY56	5322 130 40325	4	TS103, TS203, TS210, TS223
BCY71	5322 130 40373	6	TS104, TS105, TS108, TS225, TS226, TS228
ECY89	5322 130 30188	1	TS106
BSX20	5322 130 40417	3	TS107, TS109, TS114
BRY39	5322 130 40482	2	TS110, TS112
BCY57	5322 130 40491	6	TS111, TS113, TS206, TS208, TS224, TS229
BSX21	4822 130 40321	7	TS115...TS119, TS220, TS221
BFS21A	5322 130 40709	1	TS201 + TS 202 (transistorpair)
BCY72	5322 130 40486	4	TS204, TS205, TS207, TS209
BCY87	5322 130 40423	1	TS211
BFY50	5322 130 40294	1	TS222
2N2905A	5322 130 40468	1	TS227

Dioden

BAX13	4822 130 40182	33	GR101, GR102, GR104, GR107...GR122, GR124, GR130, GR201, GR202, GR210...GR213, GR233...GR236
BZY88-C3V6	4822 130 30342	2	GR103, GR105

Type	Ordering number	Qty	Item
BZY88-C5V6	4822 130 30193	1	GR106
BZY88-C6V2	4822 130 30286	1	GR123
BAX17	5322 130 30605	3	GR125, GR224, GR228
BAV10	5322 130 30594	2	GR206, GR207
BZY88-C7V5	4822 130 30287	5	GR203...GR205, GR223, GR227
BY126	4822 130 30192	2	GR208, GR209
BY179	5322 130 30521	1	GR220
BZX61-C56	5322 130 30566	4	GR221, GR222, GR225, GR226
BY164	4822 130 30414	2	GR229, GR232
BZY88-C6V8	4822 130 30079	2	GR230, GR231
BZZ16	5322 130 30136	1	GR237
Integrated circuits			
FCJ121	5322 209 80098	3	IC101, IC109, IC110
FCH191	5322 209 80032	1	IC102
FJL101	5322 209 80119	3	IC103, IC104, IC105
FCJ141	5322 209 80163	6	IC106, IC107, IC108,IC111, IC112, IC113
FCJ111	5322 209 80042	1	IC114
TAA293	5322 209 80084	1	IC115

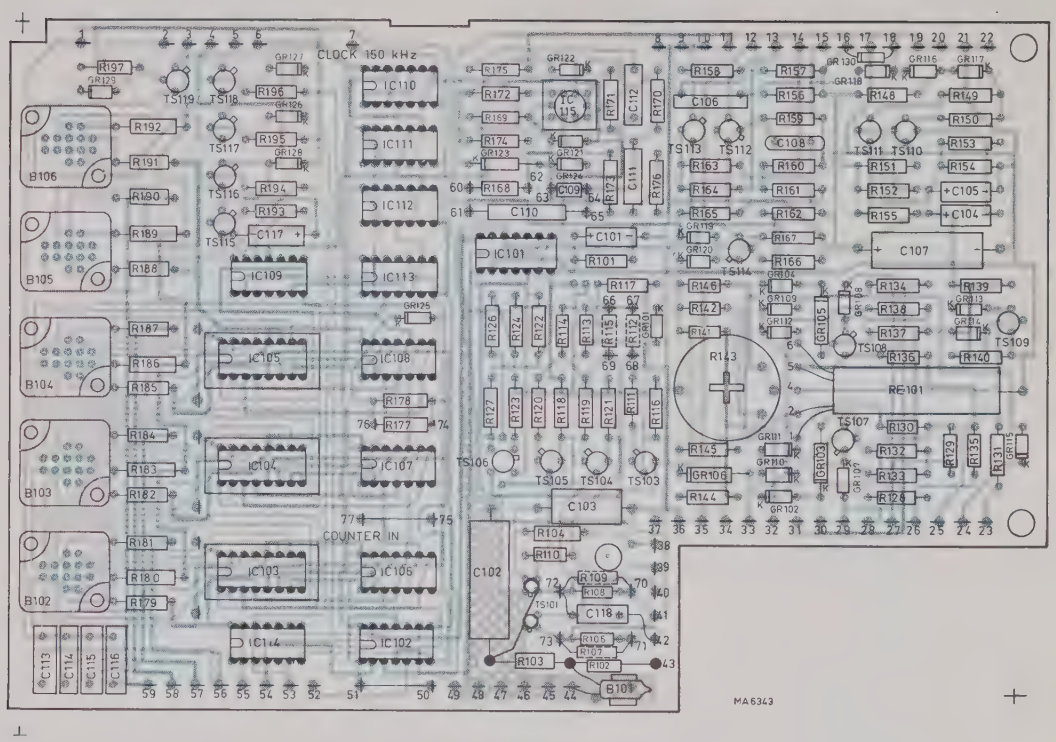


Fig. 37. Printed wiring board U1

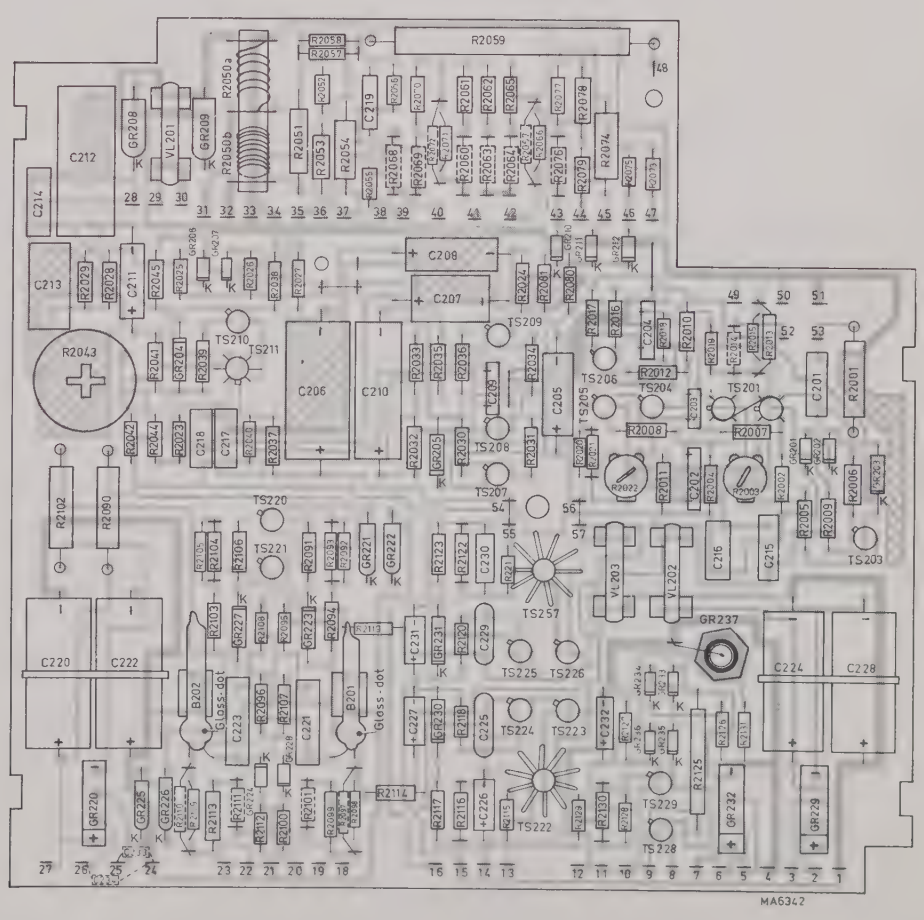


Fig. 38. Printed wiring board U2

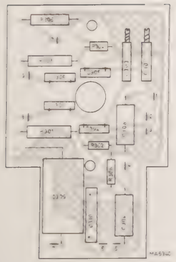


Fig. 39. Printed wiring board U2
Printpunktbelegung
Platine : implantation U2

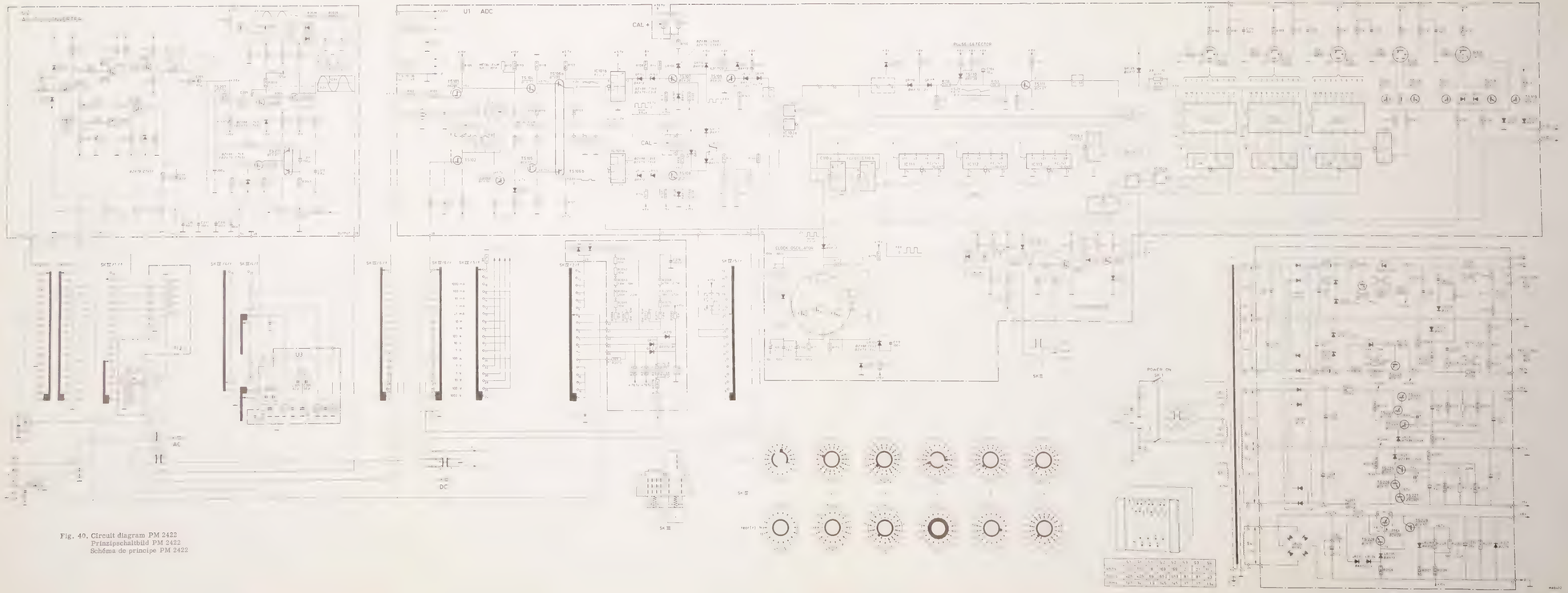


Fig. 40. Circuit diagram PM 2422
Prinzipschaltbild PM 2422
Schéma de principe PM 2422

QUALITY REPORTING

CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

LOCATION

□□□
Unit number
e.g. 000A or 0001 (for unit A or 1; not 00UA or 00U1)

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

CATEGORY

□

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

COMPONENT/SEQUENCE NUMBER

□□□□

Enter the identification as used in the circuit diagram, e.g.:

GR1003	Diode GR1003
TS0023	Transistor TS23
IC0101	Integrated circuit IC101
R0....	Resistor, potentiometer
C0....	Capacitor, variable capacitor
B0....	Tube, valve
LA....	Lamp
VL...	Fuse
SK....	Switch
BU....	Connector, socket, terminal
T0....	Transformer
L0....	Coil
X0....	Crystal
CB....	Circuit block
RE....	Relay
ME....	Meter, indicator
BA....	Battery
TR....	Chopper

Parts not identified in the circuit diagram:

990000	Unknown/Not applicable
990001	Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002	Knob (incl. dial knob, cap, etc.)
990003	Probe (only if attached to instrument)
990004	Leads and associated plugs
990005	Holder (valve, transistor, fuse, board, etc.)
990006	Complete unit (p.w. board, h.t. unit, etc.)
990007	Accessory (only those without type number)
990008	Documentation (manual, supplement, etc.)
990009	Foreign object
990099	Miscellaneous

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